# CORDOVA WATER SUPPLY FEASIBILITY STUDY

for

CITY of CORDOVA, ALASKA



MERRELL & ASSOCIATES / BLACK & VEATCH

JANUARY 1980

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TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

# Chapter 1
# INTRODUCTION

The City of Cordova, Alaska, in recent years, has gradually faced problems with respect to the reliability and dependability of the existing water supply system. These problems have been created by the growth of the fishing industry and some growth in the community itself. Recent improvements to the existing supply systems have helped, but they still are unable to provide the dependability and reliability necessary for both water supply and distribution. Problems with the adequacy of existing supply sources will become compounded when seafood canneries, which are the major water-using industries in the community, expand their operations to year-round processing. The need for a more dependable and reliable water supply for the community, as well as the need to provide increased water for the canneries on a year-round basis, has necessitated additional planning for the provision of increased water supply sources for the community.

Presently, the City of Cordova provides water as far north as the City docks, as far south and west as Whiskey Ridge Subdivision off Whitshed Road, and as far east as Eyak Lake, both along the copper river Highway near Murcheson Falls Creek and along Lake Avenue near Nirvana Park.

## AUTHORIZATION

Based on an awareness of the need for additional and more dependable water supplies, the City of Cordova decided to undertake a comprehensive analysis of the total needs for water supply for the community. On July 25, 1979, the City of Cordova entered into an agreement with Merrell & Associates Design Service/Black & Veatch, a joint venture, to study all possible water supply sources for the community and to prepare a report outlining a recommended program for developing the most cost-effective water supply system.

## PURPOSE AND SCOPE

The primary purpose of this study is to evaluate the long-range as well as immediate needs of the Cordova area for water supply facilities.

In addition, this study investigates and recommends solutions to operational problems and provides the guidelines for the phased construction of a project which will implement recommended water source plans for the community. Cost figures used in this report are planning-level estimates used for comparison of alternatives. When the recommended plan is implemented and preliminary design is undertaken, the cost will be refined.

To achieve these fundamental purposes and aims, the scope of the study includes, but is not limited to, the following:

1. Collection, review, and evaluation of existing data pertinent to the development of a dependable water source for the community.

2. Development of a program for the collection of supplemental data required as a result of insufficient basic data.

3. Review of all potential sources of water supply which could be used by the community.

4. Development of alternative water source systems, which would provide the community with a dependable supply.

5. Preparation of planning-level cost estimates for both the construction and the operation and maintenance of the recommended facilities.

6. Comparison of alternative systems based on construction costs, reliability, and flexibility. The evaluation of operation and maintenance costs would look specifically at the total manpower and skill levels required, as well as energy consumption.

7. Presentation of the results of the investigation to the public for comments and local participation.

8. Preparation of a report, delineating the recommended water source plan for the community.

## ACKNOWLEDGMENTS

Throughout this investigation, a close liaison has been maintained with the staff of the City of Cordova. This was accomplished through progress review meetings held at important stages of the study and through continuous liaison with staff members of the various City departments. Through their review and comments, the City staff has added significantly to the completeness and usefulness of this water source feasibility study.

We wish to give special thanks to those members of the City staff who worked with the staff of Merrell & Associates Design Service/Black & Veatch during the development of this water source feasibility plan. In particular, we wish to recognize Mr. Perry Lovett, City Manager, and Mr. Malcolm (Mac) McMasters, Utility Superintendent, for their valuable assistance throughout the study. In addition, we wish to thank Mr. Jay Reese for his assistance in the evaluation of the existing water supply facilities; Mr. Douglas Bectel, Manager of the Cordova Electric & Telephone Cooperative, for his assistance in our evaluation of current electrical utility costs; and Cordova Fire Department Chief, Dewey Whetsell, for his assistance in our evaluation of the current I.S.O. fire ratings.

# Chapter 2

# EXISTING WATER SUPPLY

This chapter contains a brief description of the existing water supply facilities for Cordova, Alaska. The existing system includes source, transmission, distribution, and storage facilities. Source facilities are those that divert the water from its natural course into the system. Transmission facilities transport the water from the point of diversion to the community system. Distribution facilities are those facilities within town that provide service to the individual residences, businesses, and industries. Storage facilities operate in conjunction with the distribution system to provide reserve supply for fire demands, fluctuating demands, and emergencies.

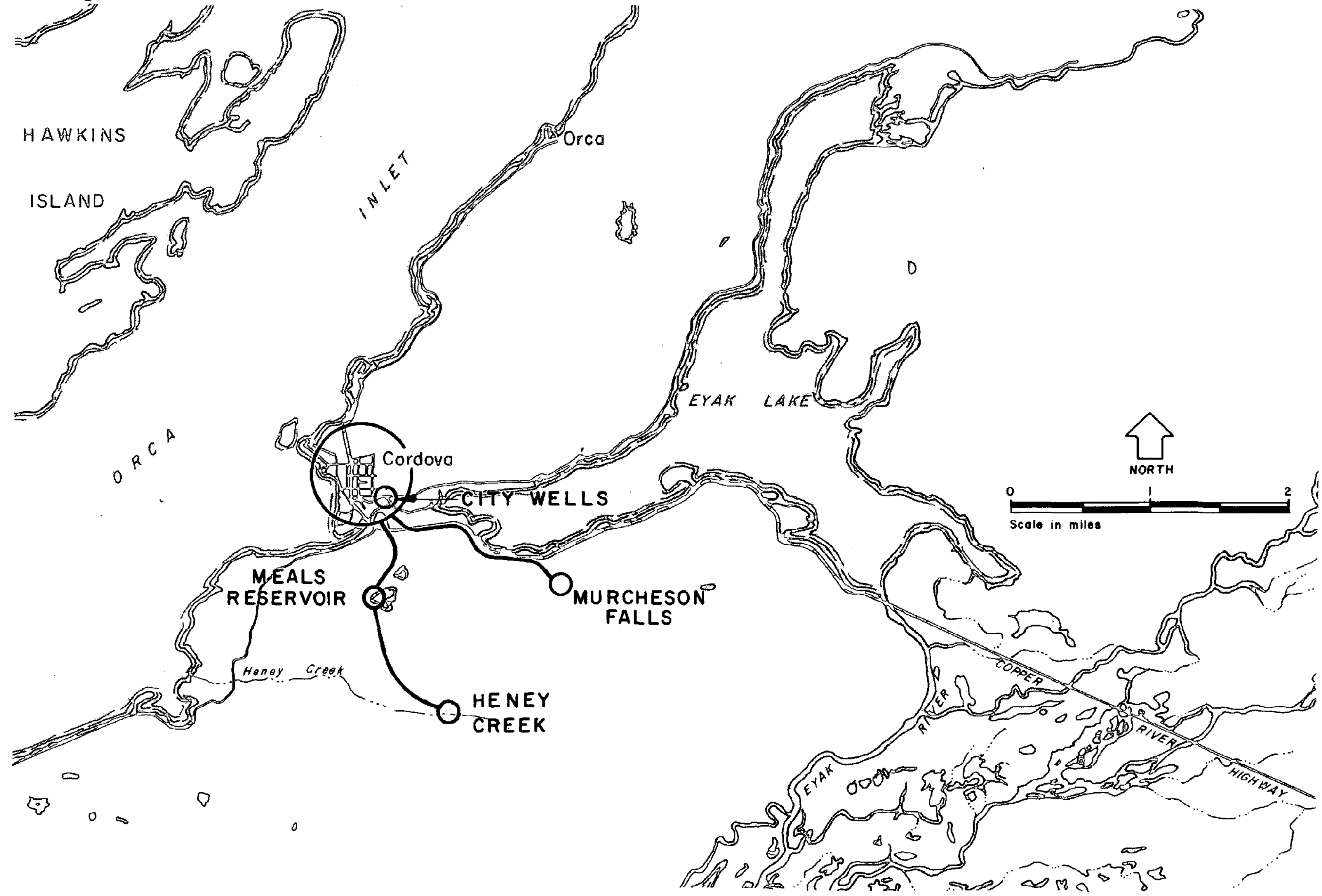
## SOURCE AND TRANSMISSION FACILITIES

The two principal sources of water supply presently in use are Heney Creek and Murcheson Falls Creek. A third source, presently in use for emergency and peak-flow demands only, is the two wells located near the western end of Eyak Lake. These water supply and transmission facilities are shown schematically in Figure 2–1, and are discussed below.

### Heney Creek Supply

Heney Creek presently furnishes a major portion of the water supply needs of Cordova. The Heney Creek diversion facilities are located in the upper reaches of Heney Creek. The diversion structure is a log crib dam, located in the mainstream channel at an

Figure 2 - 1 EXISTING WATER SUPPLY SYSTEM



elevation of approximately 400 feet. The catchment facilities divert water into a 10-inch transmission pipeline which discharges into Meals Reservoir.

In 1964, the original 12-inch woodstave pipe transmission line was replaced with 10-inch PVC. In 1974, approximately 800 feet of the 10-inch PVC pipeline, located in the side of the canyon wall, was replaced with a 10-inch ductile iron pipe, located in the streambed. The 10-inch PVC pipeline runs the remainder of the distance to Meals Reservoir. The diversion facility and the first section of pipe leaving Heney Creek Canyon were installed in very rough and unstable terrain, which is virtually inaccessible during the winter months.

Historically, the section of the Heney Creek transmission line between the catchment and Meals Reservoir has been a continual maintenance and repair problem because of the limited accessibility, particularly in the winter months, and severe geologic conditions.

An important element of the Heney creek supply facilities is Meals Reservoir. After improvements in 1974, Meals Reservoir has a useful capacity of approximately 17 million gallons. Meals Reservoir acts as an equalizing storage reservoir between the supply point and the distribution system. The water-surface elevation of Meals Reservoir is approximately 380 feet, providing more than adequate hydraulic pressure to serve the major portion of the community lying below approximate elevation 125.

Water from Meals Reservoir is transported via a 10-inch PVC and a 10-inch woodstave pipeline to the distribution main in Whitshed Road. Just prior to entering the distribution main, the flow goes through a chlorination and pressure-regulating station. Originally, the pressure-regulating valve was intended to control the pressure in the distribution system by automatically regulating the pressure from Meals Reservoir. At the present time, the valve is inoperative and the system is being controlled manually. In addition to the pressure regulation which is required at this point, there is a manually-operated chlorination facility for disinfecting the water from Meals Reservoir. The transmission main leading from this chlorination and pressure-regulating station to the City distribution system is the original 10-inch woodstave pipe, constructed in 1957, which is apparently in good condition.

### Murcheson Falls Creek Supply

The second major source of supply at the present time is from Murcheson Falls Creek. Murcheson Falls Creek diversion facilities are located approximately one and one-half miles east of town along Copper River Highway on the northern slopes of Mount Eccles. The diversion structure is a small concrete catchment dam, located at the top of Murcheson Falls. The dam has been in service since the early 1900s with only minor modification during the early 1960s.

Intake facilities consist of a 12-inch line with a shutoff valve and intake screen. The intake facilities discharge directly into a 12-inch cast iron line, transporting the water to the City distribution system. The existing facility must be manually cleaned quite often as a result of the catchment filling with gravel, small rocks, and debris. The intake screen is also plagued with plugging and must be periodically cleaned of leaves and debris.

The transmission line from Murcheson Falls catchment to the distribution system passes through a chlorination station located on LeFevre Street near the power plant, and then continues up to a 100,000-gallon steel reservoir near Fifth Street between Adams and Browning Avenues.

As originally designed, the storage tank was used to provide contact time following chlorination. Because the supply from Murcheson Falls must first go through the reservoir before entering the distribution system, and because the maximum water surface in the reservoir is at the same elevation as the source of supply, the community is able to utilize only a small portion of the supply potential from Murcheson Falls Creek.

### Well Supply

The City currently has two wells connected to the distribution system. These two wells are located immediately north of Chase Avenue near LeFevre Street and on the easterly boundary of Odiak Park Subdivision. The water quality of both wells is poor when compared to Murcheson Falls Creek and Heney Creek sources. High concentrations of sulfides and iron, as well as low yields and high power consumption required for pumping, make this source less desirable than the surface supplies. Consequently, this supply is used only for emergencies and to accommodate peak system demands.

## DISTRIBUTION AND STORAGE FACILITIES

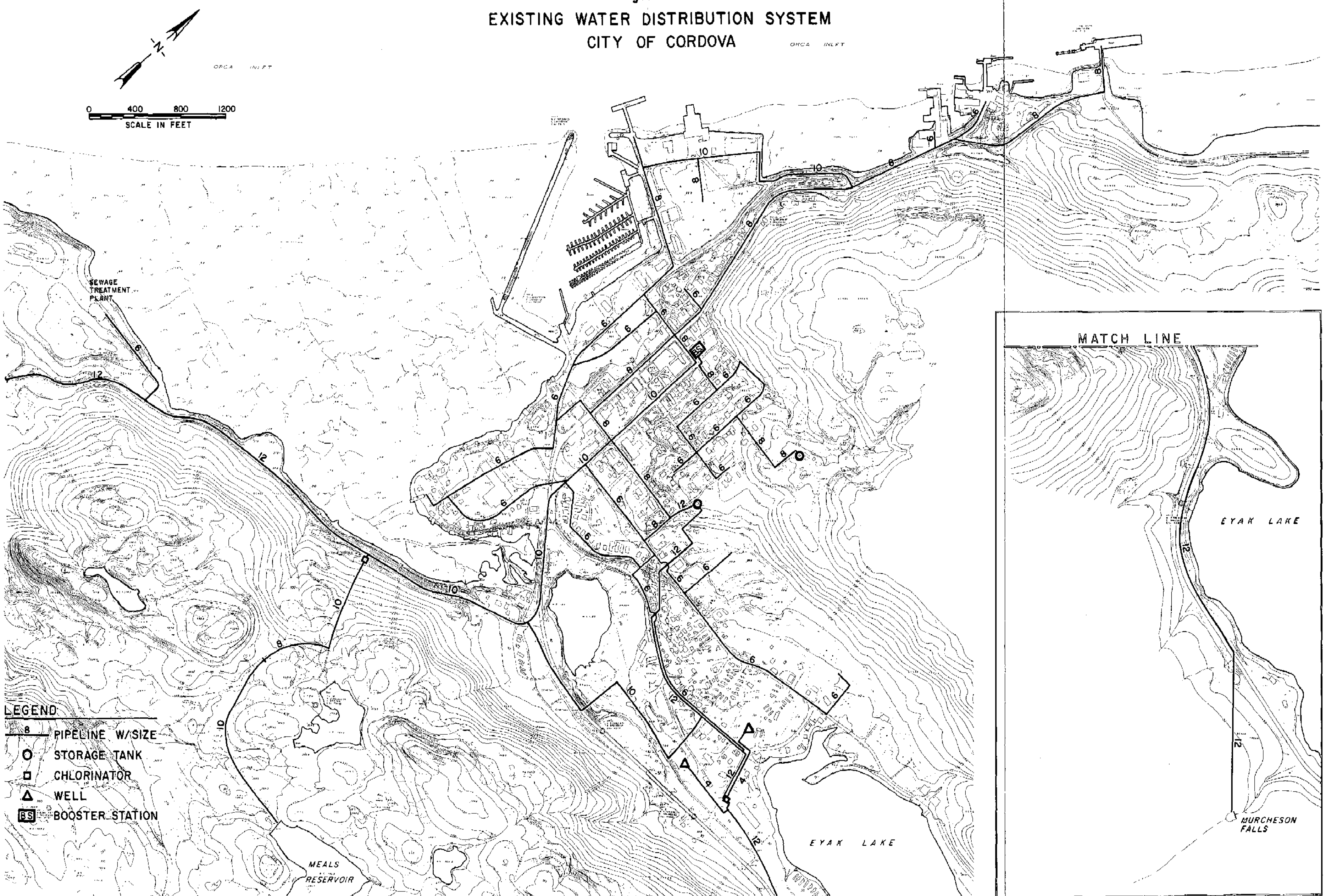
The distribution system for Cordova consists of woodstave, cast iron, ductile iron, and PVC pipe, varying in diameter up to 12 inches. The system presently serves the area from Whiskey Ridge Subdivision on Whitshed Road to the City dock, and from the boat harbor and shore area on Orca Inlet to the development adjacent to the west end of Eyak Lake. The existing distribution facilities are shown in Figure 2–2.

Included in the distribution system is the 100,000-gallon storage reservoir located near Fifth Street between Adams and Browning Avenues, and a 60,000-gallon tank located on Sixth Street between Council and Orca Avenues. The 100,000-gallon reservoir operates in conjunction with the main distribution system serving most of the town, while the 60,000-gallon reservoir serves a second higher zone. Water is supplied to the second zone system from a booster station out of the lower zone system. The booster station contains two pumps with capacities of 220 gpm and 330 gpm that are controlled by pressure sensors located near the station. The booster station is located in the basement of the Old City Hall.

In recent years, there has been a significant increase in the water demands created by increased activity in the fishing industry in the Cordova area. Consequently, the distribution system, as well as the supply sources, have been heavily taxed. The much higher demands will require upgrading the distribution system in conjunction with the development of more dependable sources of supply.

As originally designed, all water coming from the Murcheson Falls supply had to go through the 100,000-gallon storage reservoir. Diversion of this water through

Figure 2-2
EXISTING WATER DISTRIBUTION SYSTEM
CITY OF CORDOVA



the reservoir created a restriction in the distribution system, limiting the quantity of water that could be supplied from Murcheson Falls. The recent installation of the 10-inch line through Odiak Park Subdivision did provide a direct tie between the Heney Creek and the Murcheson Falls supply lines. This addition is not likely to increase the amount of water entering the distribution system from Murcheson Falls, but should help stabilize pressure in the area.

In order to make the most efficient use of existing and future water supply sources, it will be necessary to make additions and improvements to the distribution system. Necessary improvement should be designed with the aid of a computer network analysis. The computer analysis will guarantee the most efficient and cost-effective design of system improvements.

# Chapter 3

# WATER SUPPLY REQUIREMENTS

In order to properly size and develop a major water source for the community of Cordova, it is necessary to determine the existing and future water demands. Total daily and seasonal demands are the most important parameter with regard to source development, while short-term demands are most important for the design of distribution and storage facilities.

Future planning and projected growth information for Cordova were derived from existing planning documents used by the City. These reports and documents are listed in the Appendix of this report.

Two major categories of water uses for Cordova are domestic and industrial. The domestic demand includes both residential and commercial uses, while the industrial demand is composed primarily of the major water-using industries along the water front. At present, these include Bayside Cold Storage, St. Elias Cannery, Northern Pacific Cannery, and Mor Pac Cannery.

Projections of residential and commercial demands were derived from three basic sources.

1. The evaluation of past projections made in other documents and reports.

2. The evaluation of demands in similar communities.

3. The evaluation of background data from City personnel presently responsible for the operation of the existing water system.

Industrial demands were derived from overall water-use figures from the community and from special flow-monitoring performed for this study.

Based on present planning data and on the water-use characteristics considered during this report, existing and future water demands have been determined. The projected demands are shown graphically in Figure 3-1, and are summarized in Table 3–1.

As shown in the tabulation of projected flows, the residential and commercial demand is expected to increase from the present 0.3 million gallons per day (mgd) to 0.8 mgd by the year 2000. At the same time, the present industrial demand of 1.8 mgd is expected to increase to 2.7 mgd. This increase in industrial demand is based upon a projected 100% increase in the units of fish processed by the industries and an assumed 25% decrease in the rate of water consumption per unit of fish processed. The assumed decrease would come from water conservation and process changes.

Maximum hourly demands are also shown in Table 3-1. They represent a 100% increase over maximum daily demands for residential and commercial users, and a 50% increase over maximum daily demands for industrial users. The total quantity of water that will be required by the year 2000 is 3.5 mgd. An important consideration used for development and analysis of the water supply alternatives is that industrial water demand will persist throughout the year as a result of increased winter production by the industries.

Figure 3-1 PROJECTED WATER DEMANDS CORDOVA, ALASKA

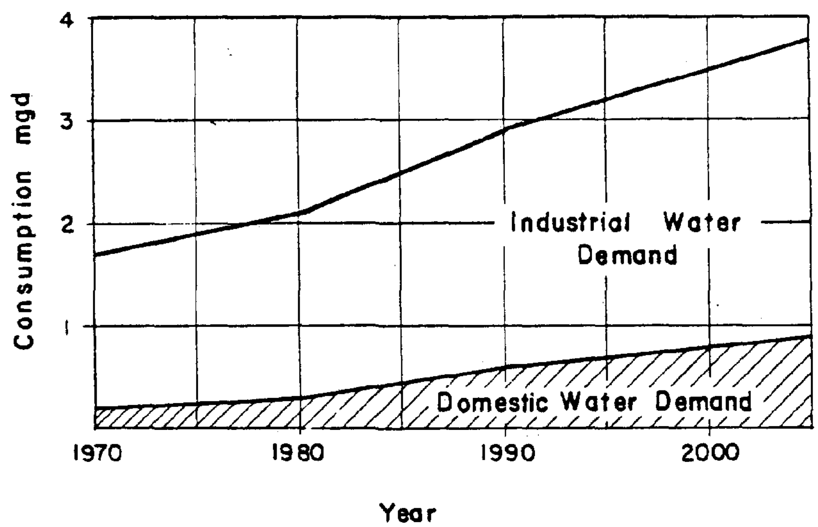



Table 3-1 PROJECTED WATER DEMANDS CORDOVA, ALASKA

| Category | Year 1980 | Year 1990 | Year 2000 |
|---|---|---|---|
| Projected Population | 2,780 | 4,000 | 5,000 |
| Projected Domestic Demand | .30 mgd | .60 mgd | .80 mgd |
| Projected Industrial Demand | 1.8 mgd | 2.3 mgd | 2.7 mgd |
| Projected Total Demand | 2.1 mgd | 2.9 mgd | 3.5 mgd |
| Projected Peak Demand | 3.3 mgd | 4.7 mgd | 5.7 mgd |

# Chapter 4

# WATER SUPPLY SOURCE

## GENERAL

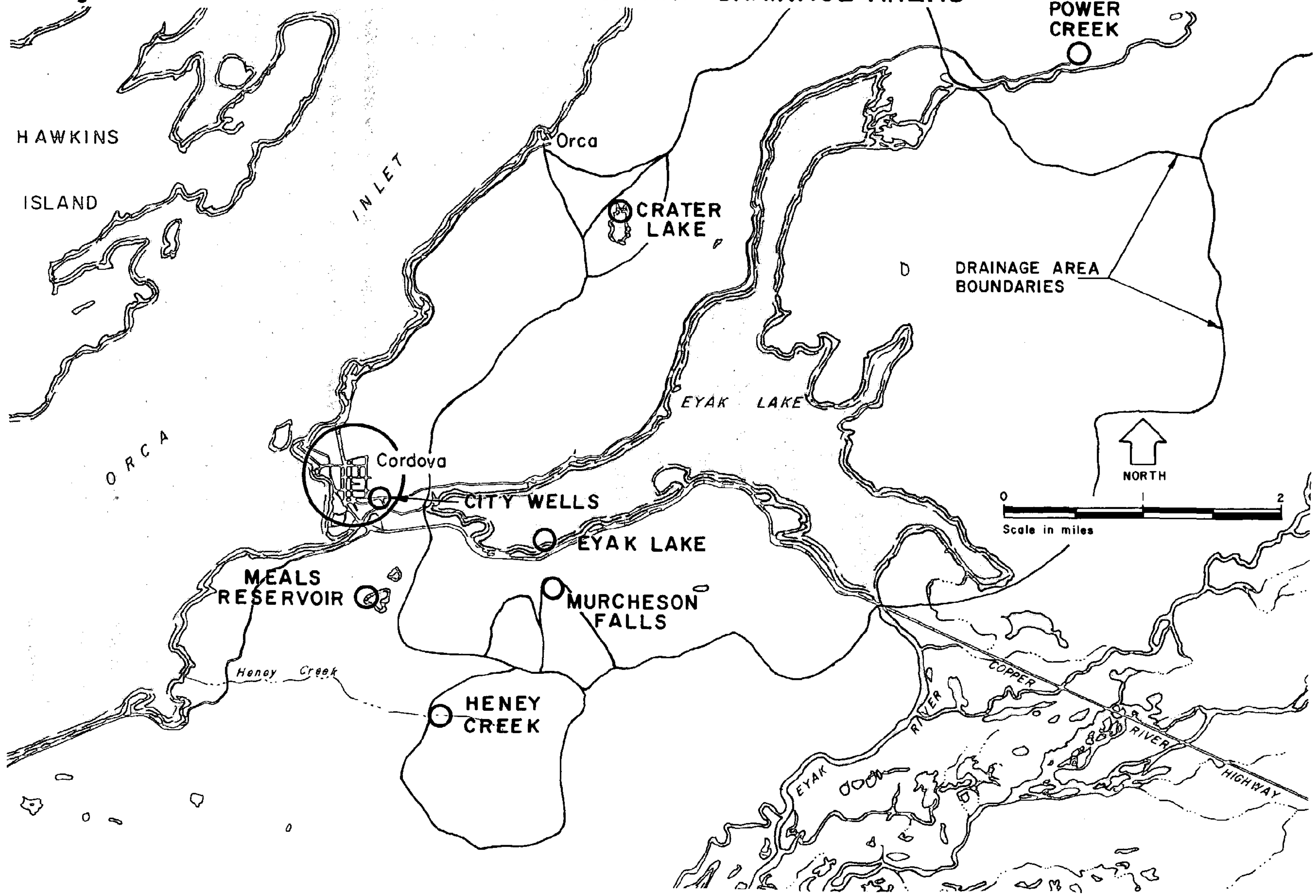
The sources of water investigated as primary supplies included Heney Creek, Murcheson Falls Creek, Power Creek, Crater Lake, Eyak Lake, and wells. Figure 4-1 shows the location of the alternative water sources. Also shown is the relative distance from each of the supply points to the City and to the closest point of access. Accessibility is very important when considering operation and maintenance of diversion and transmission facilities. The Murcheson Falls supply source, for example, is relatively close to town and is adjacent to Copper River Highway, making it quite accessible. The Heney Creek supply, on the other hand, is quite remote from town and its accessibility is very limited.

Each of the alternative supply sources was evaluated for its ability to provide adequate water in terms of both quantity and quality, with an additional emphasis on the possibility of a compatible power-generation facility.

## HYDROLOGIC FACTORS

As can be seen in Figure 4-1, the drainage area for Eyak Lake is quite large, approximately 20 square miles. The drainage area for Power Creek, not entirely shown in Figure 4-1, is also about 20 square miles. Drainage areas for Crater Lake, Murcheson Falls Creek, and Heney Creek are relatively small by comparison.

Figure 4-1 WATER SUPPLY SOURCES AND DRAINAGE AREAS



Although hydrologic data does exist for the stream flows in some of these tributaries, no attempt has been made in this study to determine the exact amount of maximum flows. In developing a reliable supply source for Cordova, the minimum flow rate that can occur in any of the tributaries is the most important factor used in the determination of the availability and dependability of a potential supply. The maximum flows would influence only the design of the facilities required to develop the supply, e.g., the sizing of dams and spillways. Based on the minimum flow rates observed, Power Creek and Eyak Lake represent the only year-round supplies. Crater Lake, Murcheson Falls Creek, and Heney Creek are not dependable year-round supplies because their flows are subject to severe reductions at certain times of the year, principally due to freezing during prolonged periods of cold weather.

## WATER QUALITY FACTORS

An important factor with regard to the ease with which a surface water supply may be developed is the quality of the runoff that occurs in the drainage basin. This varies considerably for the different sources being investigated. Murcheson Falls Creek and Crater Lake have tributary areas which are almost void of soil erosion problems and, consequently, even during high runoff, they remain quite clear. The Heney Creek supply is subject to some minor siltation during high runoff periods. Power Creek, on the other hand, is fed by glacial runoff and is very turbid, even to the point of being milkylike during high runoff periods. Eyak Lake, which is fed primarily by Power Creek, acts as a settling basin, and many parts of the lake are quite clear, even though the incoming flow from Power Creek is turbid.

Water quality characteristics of each alternative water source were investigated during this study. Water quality information was derived from existing reports and douments referenced in the appendix and from testing performed specifically for this study. Table 4-1 contains a summary of the water quality characteristics for each of the potential water supply sources. Included in Table 4-1 is a listing of the ranges of characteristics which have been used by the United States Public Health

Table 4-1. QUALITY CHARACTERISTICS OF WATER SOURCES

| Source | Total Coliform MPN | Total Dissolved Solids mg/l | pH Units | Turbidity NTU |
|---|---|---|---|---|
| Public Health Service* | 0-100 | 100 | 6.0-8.5 | 0-10 |
| Murcheson Falls | 3 | 35 | 6.8 | < 2 |
| Meals Reservoir | 5 | 40 | 6.9 | < 5 |
| Eyak Lake (Average) | 16 | 35 | 6.7 | <10 |
| Eyak Lake (Near Murch.) | 4 | 41 | 6.9 | <10 |
| City Wells | 0 | 95 | 7.5 | <10 |
| Crater Lake (at Orca) | 9 | 44 | 7.3 | <2 |
| Power Creek | 20 | 30 | 7.1 | > 10 |

*Excellent source of water supply
Ref: U.S.P.H.S.

Service to designate an "excellent raw water source." A water source whose quality characteristic falls within this range is likely to require minimal or no treatment, except for disinfection in the case of surface water supplies.

The water quality data presented in Table 4-1 demonstrates the fact that all of the potential sources of water available to Cordova are within the so-called "excellent raw water source" range, and, certainly, all are capable of being treated to an acceptable level of drinking water quality.

In order to provide additional water quality data necessary to evaluate the use of Eyak Lake as a source of supply, a special sampling and testing program was conducted during the preliminary stages of this study. The sampling and testing program involved sounding and sampling of Eyak Lake at several locations. The sample points are

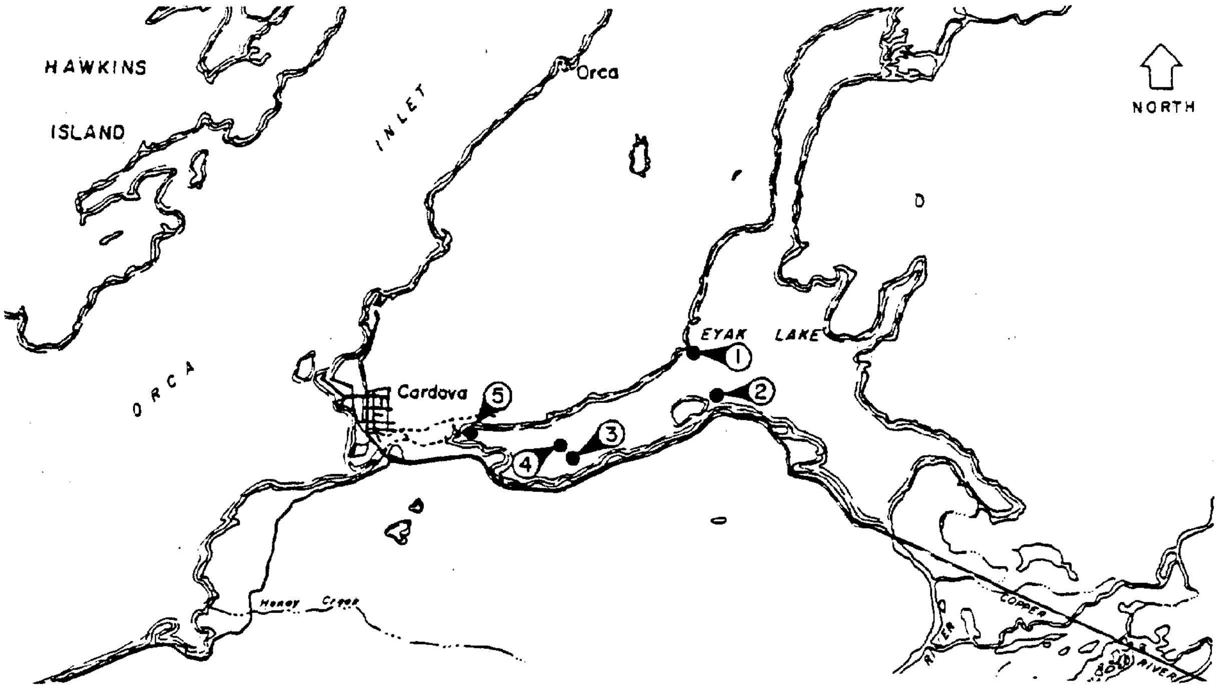
delineated in Figure 4-2, and results of the testing of these samples are shown in Table 4-2. As can be seen from Table 4-2, there is a definite decrease in the quality of water, particularly with respect to turbidity and coliform bacteria, at the extreme westerly end of the lake. One probable cause for the higher coliform count at this location was the fact that the samples were taken at the shoreline during the spawning season and there were numerous dead salmon, both floating near shore and lying along the beach at the time the samples were taken. This fact alone could account for the presence of the high coliform bacteria count. In any case, these higher counts were not found at any other sample location on the lake.

Previous water quality data for Eyak Lake also indicated that the water quality was poorest in the most westerly end of the lake and that the poorer quality was attributable to pollution resulting from the residential development adjacent to the lake. Since that time, a wastewater collection and treatment system has been installed in Cordova and the most likely potential causes of the pollution (septic tank leach systems) have been removed by connection to the sewer system in this vicinity.

To further define the water quality parameters of Eyak Lake during the winter months, a testing program has been initiated. The testing program is intended to answer questions regarding the possible buildup of pollutants under the ice when the lake is frozen over. Testing will continue through the winter and the information gained will be used to better define the type of treatment necessary. At the writing of this report, the first set of data from the winter-testing program is available. The test results are summarized in Table 4-3. First results indicate that there is not a buildup of any pollutants under the ice at the proposed location of a treatment plant intake near sample point No. 3 shown in Figure 4-2. Further testing throughout the 1979-80 winter is expected to confirm these preliminary findings.

In summary, our investigation of the water quality of each potential source indicates that Murcheson Falls Creek, Heney Creek-Meals Reservoir, and Crater Lake supplies will require only disinfection for treatment. The Eyak Lake water source, although

## Figure 4-2 EYAK LAKE WATER QUALITY SAMPLING RESULTS




## Table 4-2 EYAK LAKE WATER QUALITY SAMPLING RESULTS

| | Total Coloform (a) | Total Dissolved Solids | pH | Turbidity |
|---|---|---|---|---|
| | MPN | mg/l | units | NTU |
| Public Health Service | 0 | < 100 | 6.0-8.5 | 0-10 |
| Eyak Lake Sample #1 | 12 | 6 | 6.7 | < 5 |
| Eyak Lake Sample #2 | 0 | 8.5 | 6.7 | < 5 |
| Eyak Lake Sample #3 (b) | 14 | 24 | 6.6 | < 5 |
| Eyak Lake Sample #4 | 25 | 19 | 6.6 | < 5 |
| Eyak Lake Sample #5 (c) | 530 | 22 | 6.7 | <10 |

(a) Avg. of Samples Taken Aug. & Sept.
(b) Proposed Water Treatment Plant Site
(c) Past Emergency Water Source

Table 4-3. EYAK WATER QUALITY TESTING - WINTER 1979-80
(Test Results for December 12, 1979, Samples)

| Sample Location | Odor (obs) | Color (obs) | Coliform MPN | TS mg/l | TSS mg/l | Turb. NTU |
|---|---|---|---|---|---|---|
| (Figure 4-2, Point No. 3) 35' off-shore near future WTP site (average 2 samples) | None | None | 3 | 38 | 5 | 6 |
| (Figure 4-2, Point No. 3) 65' off-shore near future WTP site (average 2 samples) | None | None | 5 | 43 | 6 | 6 |
| (Figure 4-2, Point No. 5) 10' off-shore near the Powerhouse | None | None | 17 | 34 | 6 | 7 |

of good quality, is susceptible to pollution and, therefore, will require more complete treatment. The required treatment would include sand filtration, carbon filtration for occasional taste and odor control, and disinfection. The water from Power Creek is definitely of good quality; however, the high turbidity resulting from glacial runoff will require treatment, including sand filtration, disinfection, and perhaps some chemical additions during portions of the year. The City wells have a poorer quality of water than the other supplies, including taste and odor problems that are not a part of the water quality tabulation shown in Table 4-1. Due to poor quality and low yields, the wells are not considered a viable alternative source of water for the City, except as an emergency supply.

## POWER GENERATION FEASIBILITY

In an attempt to investigate all sources of power for the community of Cordova that might be less expensive than the current production by diesel generators, this study included a very preliminary consideration of the feasibility of providing hydro power from, or as a part of, the development of a water supply source for the community. The potential for the development of hydro power was considered with each alternative. In each case, the objective was to study the feasibility or possibility that a power supply project could be incorporated with a water supply project in order to produce a compatible and less costly means of generating power.

As a result of our investigations, we have reached the following conclusions.

1. The feasibility of developing a Power Creek power project has been documented in prior studies. Additional studies are currently under way to determine if an adequate site exists to place a dam in Power Creek Canyon. Because the magnitude of the power project far overshadows the water supply aspects of a joint project, no further consideration was made of a joint project in this report.

2. Development of Murcheson Falls Creek as a source of power was found to be not feasible. There is insufficient head in the tributary area to develop a new catchment upstream of the existing Murcheson Falls Dam that would provide a source of power and still have sufficient head available to properly operate the water distribution system without pumping. The problem with the continual movement of small rocks, gravel, and debris in the streambed would also seriously hamper the development of the power supply project. Development of a catchment would necessarily have to be very elaborate in order to minimize the operational problems.

3. Development of power, using a Heney Creek catchment and/or Meals Reservoir water supply facilities, is not feasible because of the inaccessibility of the Heney Creek Canyon. The costs and risks involved in developing and maintaining a diversion dam to provide for both water supply and power are too great. Without the Heney Creek supply, Meals Reservoir would not contain sufficient water to satisfactorily operate a power-generation facility.

4. Neither the use of Eyak Lake nor the City wells would serve as a potential source of power.

5. Crater Lake is the only source of water supply that has potential for hydro power generation as part of a water supply project. The Corps of Engineers is presently conducting a detailed study of potential hydro power sites for the Cordova area. Included in their study is Crater Lake. The study will be published in 1980. The head available would support a power supply project with sufficient head remaining to allow the same source of water to be used directly in the distribution system. Because Crater Lake acts as an equalizing basin, the outflow which flows down toward Orca has a more uniform flow rate than other tributary areas such as Murcheson Falls Creek or Heney Creek. Water supply from Crater Lake is subject to winter freezing, incidentally, as is Murcheson Falls Creek.

   At the present time the water rights concerning Crater Lake are not certain. Any further investigation of Crater Lake as a water or power supply will have to include the resolution of existing and future water rights.

   Development of a water-intake structure in Crater Lake is very doubtful due to the remoteness of the site and the resulting cost of transporting the water down the rugged terrain to a power-generation site. It is possible, however, that the outflow from Crater Lake could be stabilized further by modifications to the outlet, which would optimize the useful water supply from the area tributary to the lake.

   It appears feasible to construct a joint water supply and power project on the Crater Lake supply by diverting water upstream of the existing diversion facility operated by Chugach Alaskan Cannery. Assuming that a usable supply of 3.0 mgd is available at a hydrostatic head of 450 to 500 feet, it is possible to produce approximately 75 kilowatts of power and to supply the town with 3.0 mgd of water at a pressure equivalent to that produced by the Murcheson Falls supply. This alternative is identified and evaluated in Chapter 5.

# Chapter 5

# ALTERNATIVE WATER SUPPLY SYSTEMS

## BASIC CRITERIA

Prior to developing the alternative water supply systems for the City of Cordova, a set of basic criteria was developed. These criteria were applied to all alternatives on an equal basis. The basic criteria are:

1. Water supplies must be dependable during all 12 months of the year.

2. The delivered water quality must be similar for all alternatives and must meet public health standards.

3. Adequate backup supplies must be available for emergency use.

4. All water supply systems must minimize the operation and maintenance costs, with the least amount of complexity and sophistication.

The requirement that all water supply plans incorporate a minimum amount of operations and maintenance costs is an attempt to minimize the annual cost which must be borne by the City in perpetuity.

The least amount of complexity and sophistication is desirable to insure that system facilities are capable of being operated and maintained, to the greatest extent possible, by City employees rather than by specialized technicians outside the community. All automatic equipment should be equipped with manual overrides and bypass facilities to enhance operation and maintenance.

## PRELIMINARY SCREENING OF ALTERNATIVE SOURCES

Using the information derived during the initial phases of the study and the basic criteria defined earlier in this chapter, a preliminary analysis of each of the alternative sources was performed. The results of the analysis and the conclusions which were drawn from this preliminary screening are listed below.

1. Only Eyak Lake and Power Creek can meet all of the demand requirements for a continuous 12 months per year.

2. Development of a water supply from Power Creek is not feasible without a power project.

3. Wells are not adequate as a primary supply source for the community.

4. Only disinfection will be required for the treatment of the water from Murcheson Falls Creek, Heney Creek through Meals Reservoir, and Crater Lake.

5. Treatment, primarily filtration and disinfection, will be required for both the Power Creek and Eyak Lake supplies.

6. A treatment plant on Eyak Lake will be a necessary component of all alternative plans.

7. Except for Alternative 1 which utilizes Heney Creek as a primary source, Meals Reservoir will function as a secondary supply source. Heney Creek

tributary will continue to be maintained with minimal capital improvements to the catchment facility and transmission line. These improvements will be sufficient to allow Heney Creek to serve as a secondary source to Murcheson Falls for a ten-year period.

During the winter months, or during extremely long dry periods, Meals Lake will be used as a supply source and drained to its practical limit. Once this source is depleted, Eyak Lake will be utilized. It is expected that beyond ten years, hydroelectric power will be developed wherein power costs will be reduced to the extent that pumping from Eyak Lake will be more economical.

8. When a less expensive power source is available or if a major failure of the Heney Creek catchment or transmission facility occurs, it will be necessary to reevaluate the further use of Heney Creek.

9. A parallel line from Murcheson Falls to the distribution system will be required for those alternatives utilizing Murcheson Falls Creek as a primary source of supply.

10. Several distribution system improvements, including increased storage, will be required for all alternative systems in order to most economically and efficiently develop the raw water sources.

11. The Crater Lake supply is the only source that has potential for the development of an economical joint water supply and hydro-power project.

Using the basic criteria listed before, and utilizing the results of the preliminary screening, seven alternative water supply systems were developed for further evaluation. Each of the seven alternatives is described and evaluated following the description of the common distribution system improvements and the common supply facilities required for all alternatives.

## COMMON DISTRIBUTION SYSTEM IMPROVEMENTS

As a part of all of the alternative water supply systems being evaluated, certain improvements to the existing water distribution system will be required. The common distribution system improvements include:

1. Additional storage capacity.

2. Additional major distribution mains.

3. Installation of a metering and telemetry system.

A summary of the additions and improvement and their estimated costs is presented in Table 5-1, and a description of the common distribution system improvements follows.

The additional storage requirements include three 0.5 million gallon (MG) reservoirs, located within the existing system. Each reservoir is to be so located that it has a maximum water-surface elevation of approximately 195-feet above mean sea level. Thus, the entire supply system will operate automatically at the same system pressure, which will be maintained by the individual storage reservoirs. The siting of the reservoirs within the distribution system will be an important part of the design. The location of each reservoir is critical to the efficient use of both the supply sources and the distribution system.

Additional major water distribution mains are necessary to increase the flow of water from the points of supply to the points of major water demand. No attempt has been made in this study to define the exact size or location for all necessary lines; however, lines have been included with the recommended improvements. The purpose of these lines will be to provide adequate supply at a suitable pressure during peak flow periods in the downtown area, and to generally enhance the operation of the entire distribution system.

Table 5-1. COMMON DISTRIBUTION SYSTEM IMPROVEMENTS

| | |
|---|---|
| **Capital Costs** | |
| Storage Reservoirs 0.5-MG (three required) | |
| Steel tank fabrication, erection painting | $ 870,000 |
| Site preparation and foundation | 181,000 |
| Piping and valving | 100,000 |
| Monitoring equipment | 25,000 |
| 30% Contingency, Engineering, Legal, etc. | 353,000 |
| | $1,529,000 |
| Distribution Mains | |
| 2500 feet @ $80 per foot | $ 200,000 |
| Valving | 20,000 |
| 30% Contingency, Engineering, Legal, etc. | 66,000 |
| | $ 286,000 |
| Telemetry System | |
| Receiver-Recording Equipment | $ 45,000 |
| 30% Contingency, Engineering, Legal, etc. | 14,000 |
| | $ 59,000 |
| TOTAL CAPITAL COST | $1,874,000 |
| **Annual Cost** | |
| Storage Reservoirs | $ 19,000 |
| Distribution Mains | 1,000 |
| Metering Telemetry | 9,000 |
| TOTAL ANNUAL O&M COST | $ 29,000 |

The metering and telemetry system will include metering of system flows from each of the water sources and monitoring of water-surface elevation, or volume of water, in each storage reservoir. This information will be telemetered to a central location for monitoring and recording. This equipment is needed to minimize the manpower requirements to perform these operations and to improve system dependability.

## COMMON SUPPLY FACILITIES

In addition to distribution system improvements, there are several elements of supply facilities which are required for most of the alternative supply systems. In order not to duplicate the description and cost analysis of these items in each alternative, they are included herein. The common supply facilities include:

1. A water treatment plant for Eyak Lake supply (slightly different for Alternative 2, Power Creek).

2. Parallel transmission line from the Murcheson Falls supply (not required for Alternative 2, Power Creek, and slightly different for Alternative 3, Eyak Lake).

3. The upgrading of Meals Reservoir supply line and disinfection and metering facilities.

A summary of the facilities and their estimated costs is presented in Table 5-2, and a description of the common supply facilities follows.

Since each alternative will require the use of Eyak Lake for the supply of water during winter months, installation of a 3.5-mgd water treatment plant is required for all alternatives. The major treatment processes will be pressure sand filters, an activated carbon filter, and a disinfection system.

Table 5-2. COMMON SUPPLY FACILITIES

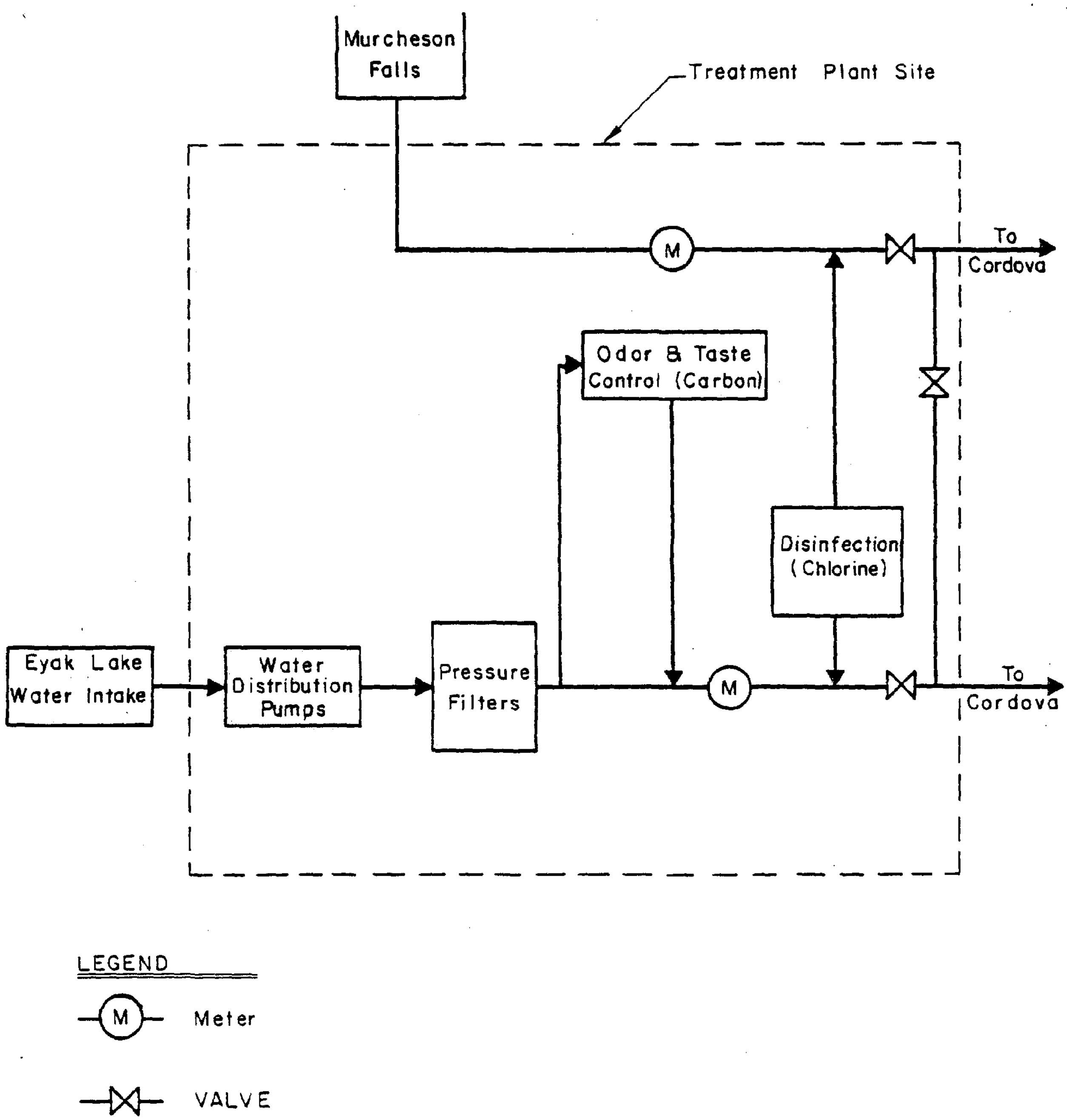
| | |
|---|---|
| **Capital Costs** | |
| **Eyak Lake Treatment Plant** | |
| Intake | $ 20,750 |
| Site Work and Foundation | 125,000 |
| Building, including electric and HVAC | 227,500 |
| Treatment Equipment - filters, disinfection carbon, etc. | 375,000 |
| Mechanical Equipment - piping and valving | 85,000 |
| | $ 833,000 |
| **Murcheson Falls Parallel Transmission Line** | |
| 5000 feet 18-inch (Alternatives 1,4,5,6,7) | $ 500,000 |
| (Deduct for 12-inch line in Alternative 3) | (75,000) |
| **Meals Emergency Supply** | |
| Minor improvements to the catchment facility and transmission line | $ 195,000 |
| Minor modifications to valve and $Cl_2$ building | 15,000 |
| Modification to intake (valve) | 10,000 |
| | $ 220,000 |
| (Add for Alternative 1 Chlorination, Valving, and Metering) | (51,000) |
| TOTAL COMMON CAPITAL COSTS | $1,553,000 |
| (without additives or deducts) | |
| **Annual Costs** | |
| **Eyak Lake Treatment Plant** | |
| Alternatives, 1, 4, and 5 (two months) | $ 74,000 |
| Alternative 2 (initially two months, then twelve months without pumping | 75,000 |
| Alternative 3 (twelve months) | 267,000 |
| Alternative 6 (four months) | 144,000 |
| **Murcheson Falls Parallel Transmission Line** | $ -- |
| **Meals Emergency Supply** | $ 2,000 |

The capital cost of the treatment plant will be similar for all alternatives, even if the treatment plant were located on the north side of the lake for Alternative 2, Power Creek. Operation and maintenance costs will vary considerably for each of the alternatives, however. The principal factor effecting the annual cost is the assumed total length of time that the facility is either in full operation or in a standby mode. The alternatives that utilize the treatment plant for a winter-only supply assume two months per year of full-time operation plus three months of standby. The Power Creek alternative assumes two months per year of full-time operation for the interim ten-year period prior to getting water from Power Creek and then 12 months per year of full-time operation, but without pumping, for the second ten years of the analysis. The alternative utilizing only Eyak Lake assumes 12 months per year of full-time treatment and pumping. The alternative that utilizes only Eyak Lake to supplement the flow from Murcheson Falls Creek assumes four months per year of full-time operation plus three months of standby.

A schematic diagram showing the major components of a typical water treatment plant is shown in Figure 5-1.

The supply of water from Murcheson Falls is limited during the periods of high demand by the hydraulic capacity of the Murcheson Falls transmission line. The hydraulic capacity is limited because the diversion facility at Murcheson Falls is at the same elevation as the water surface in the existing 100,000-gallon storage reservoir. In order to deliver additional water from Murcheson Falls to the distribution system without additional pumping facilities, it will be necessary to either raise the catchment dam or to increase the size of the transmission line. Raising the elevation of the catchment would require automatic valves on each of the storage reservoirs to prevent their overflowing and would require operating the distribution system at a higher pressure. Paralleling of the transmission line would, on the other hand, allow the system to continue to operate automatically, without control valves, and would allow the system also to effectively utilize the full capacity from Murcheson Falls Creek. The parallel line is recommended and is being used in the alternatives analyses because it provides the additional capacity from Murcheson Falls and minimizes

Figure 5-1 TYPICAL WATER TREATMENT PLANT



the operation and maintenance problems associated with a catchment upstream in Murcheson Falls Creek, and eliminates the need for higher system pressures, and automatic control valves.

The third common improvement to the water supply facilities would be the upgrading of the Meals Reservoir facilities to act as an emergency and/or secondary supply for all those alternatives which do not include Heney Creek as a major source of supply. This upgrading would consist of minor improvements to the catchment facility and the transmission line in Heney Creek Canyon and minor modifications to the metering and disinfection systems at the location where the Meals Reservoir supply enters the distribution system on Whitshed Road.

## ALTERNATIVES ANALYSIS

Each alternative water supply system is described in the following paragraphs. Planning-level estimates of construction and annual operation and maintenance costs have been prepared. <u>The costs of common distribution system improvements, Table 5-1, are not included in the alternative costs.</u> The costs, both capital and O&M, for the common supply facilities, Table 5-2, <u>are</u> included in the alternative over those distribution system improvement costs that are common to all alternatives.

### Alternative 1 - Murcheson and Heney

Alternative 1 consists of upgrading the existing water supply system, relying primarily on Murcheson Falls Creek and Heney Creek. Eyak Lake will be utilized for a winter-only supply during those periods when Murcheson Falls Creek and Heney Creek are not capable of producing a sufficient supply of water. Improvements on Heney Creek will include the construction of a new concrete catchment dam with improved intake facilities. The catchment facilities on Heney Creek are more costly than other catchment facilities being considered for other alternatives. The larger and steep tributary causes very high runoff flows and resulting streambed movement that must be contained. In addition, the remoteness of the site makes this construction very difficult. An improved access road from Whitshed Road to the crest of Heney Creek Canyon is also required. The improvements to Meals Reservoir include all the common items, see Table 5-2, and additional costs for permanent chlorination, valving, and metering structure at Whitshed Road.

Improvements at Murcheson Falls will include construction of a small diversion facility upstream of the existing dam, which will enhance the maintenance of the downstream catchment by providing a convenient way of diverting the flow away from the existing dam for repairs and maintenance and further by removing rocks and gravel ahead of the existing catchment basin. Improvements to the existing catchment and intake facilities will include improved valving and screening on the intake line and modifications behind the dam to isolate the intake from most of the gravel and debris. Besides improvements to the catchment facilities, a new larger transmission line will be installed parallel to the existing transmission main along the Copper River Highway. In the future, it may be necessary to parallel that portion of the line from Copper River Highway to Murcheson Falls Dam.

The Eyak Lake supply will require installation of a water treatment plant on the southern shore of Eyak Lake. The water treatment plant will be a pressure filter system with a capacity of 3.5 million gallons per day. A common disinfection system to handle both Eyak Lake and Murcheson Falls water supplies will also be included.

The alternative is presented graphically in Figure 5-2, with associated costs presented in Table 5-3.

Figure 5-2 ALTERNATIVE I-UPGRADE EXISTING SYSTEM

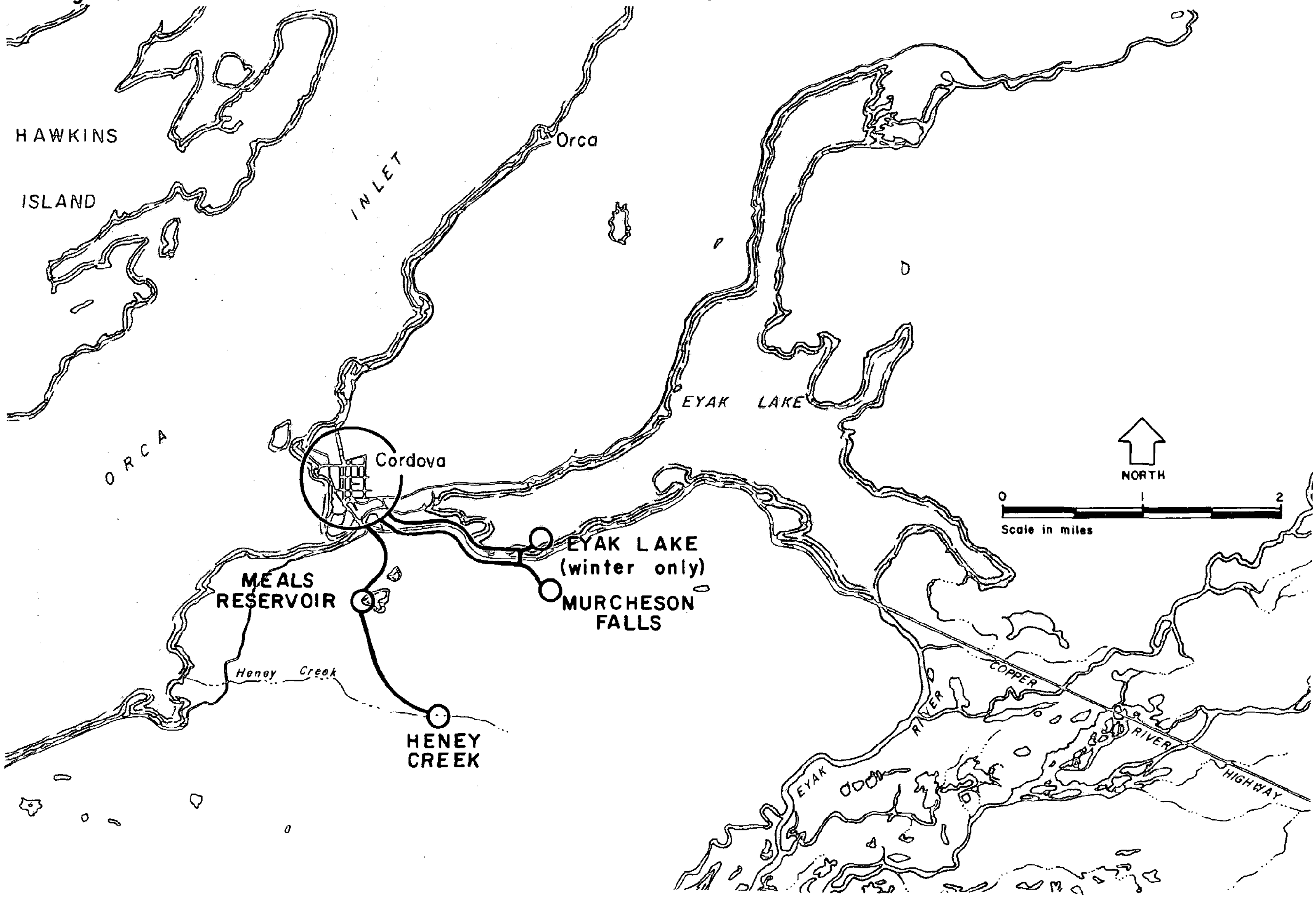


Table 5-3. COST SUMMARY - ALTERNATIVE 1
MURCHESON AND HENEY

| | |
|---|---|
| **Capital Costs** | |
| Murcheson Falls | |
| Catchment improvements | $ 85,000 |
| Transmission line, 18-inch | 500,000 |
| Heney Creek | |
| Replace catchment and intake | $ 800,000 |
| Transmission line improvements (Heney to Meals Reservoir) | 400,000 |
| Improved access (Heney to Meals Reservoir) | 100,000 |
| Eyak Lake Treatment Plant | $ 883,000 |
| Meals Reservoir (permanent improvements) | $ 271,000 |
| Total Capital Costs | $2,989,000 |
| 30% Contingency, Engineering, Legal, etc. | 897,000 |
| TOTAL ALTERNATIVE COST | $3,886,000 |
| **Annual Costs** | |
| Power | $ 34,000 |
| Personnel | 36,000 |
| Supplies, Equipment, etc. | 44,000 |
| TOTAL ANNUAL O&M COST | $ 114,000 |

Alternative 2 - Power Creek

Alternative 2 would utilize Power Creek as a primary source of water supply. Through the preliminary screening process, it was determined that it would be not feasible to develop a single-purpose water supply project on Power Creek. The cost to develop a diversion facility the size necessary to accommodate the flows in Power Creek, at a potential site that would produce sufficient head, was prohibitive even without the long transmission line necessary to get the water to Cordova. Because there is the possibility of a major power project on Power Creek, it was assumed that water could be diverted from the power project facilities at a point near the end of the existing road along the north shore of Eyak Lake. It was also assumed, for the sake of developing a realistic alternative, that this water would not be available for ten years.

In the interim, Heney Creek, Murcheson Falls Creek, and Eyak Lake would be required as supplies. Improvements at Heney Creek and Murcheson Falls Creek would be done only to the extent necessary to provide for their use during the interim period. The Eyak Lake treatment plant will be similar to other alternatives, with the exception that it would be located on the north side of Eyak Lake to facilitate the staged construction of the transmission line from Power Creek. This alternative also includes the upgrading of the existing disinfection systems for both the Heney Creek and Murcheson Falls supplies.

This alternative is presented graphically in Figure 5-3, with associated costs presented in Table 5-4.

Figure 5-3 ALTERNATIVE 2 - POWER CREEK

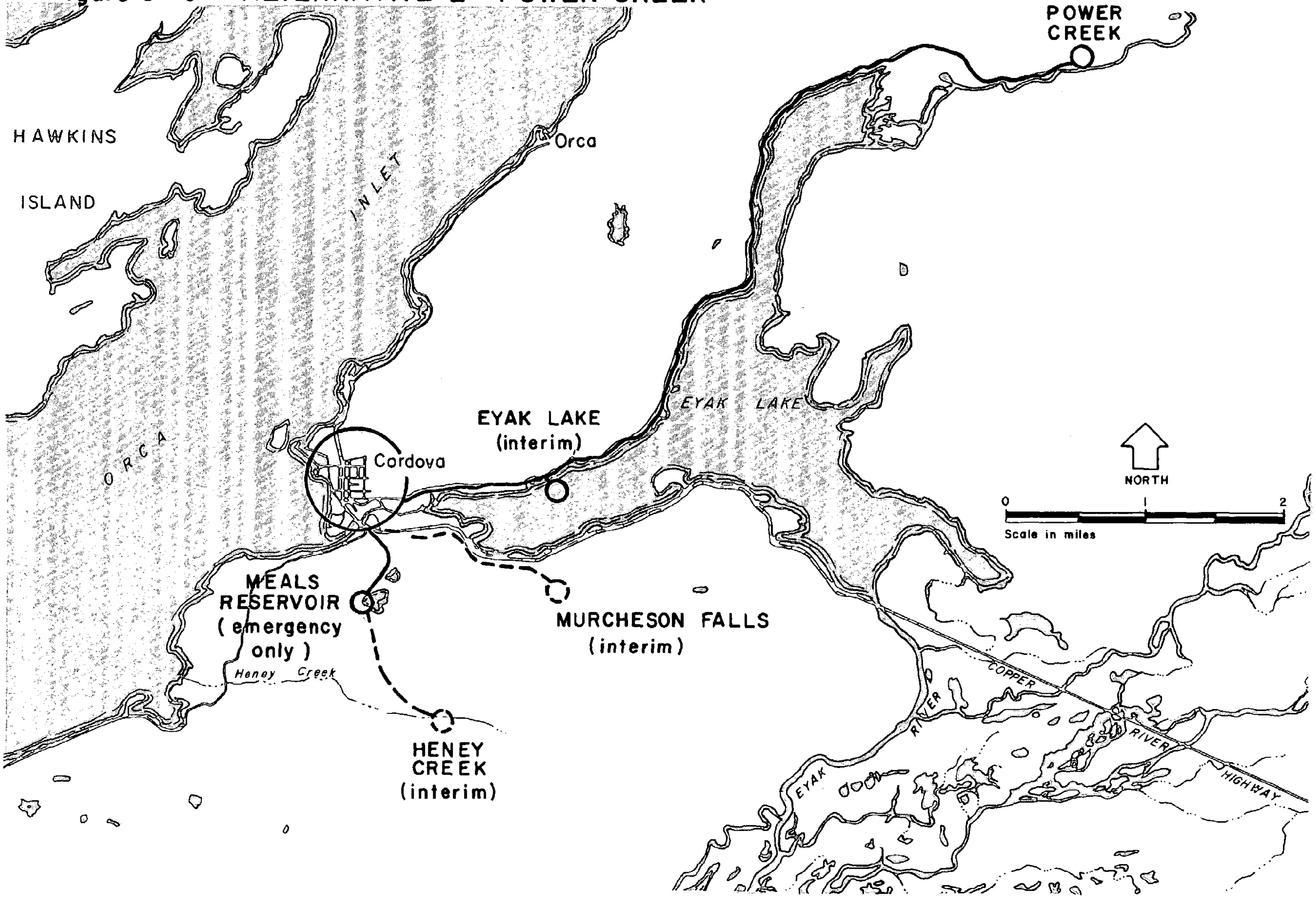


Table 5-4. COST SUMMARY - ALTERNATIVE 2
POWER CREEK

Capital Costs

| | |
|---|---|
| Power Creek Transmission Facilities | $3,550,000 |
| Treatment Plant (Eyak Lake - Interim) | 833,000 |
| Murcheson (Interim) | 50,000 |
| Meals Emergency Supply | 220,000 |
| Total Capital Costs | $4,653,000 |
| 30% Contingency, Engineering, Legal, etc. | 1,396,000 |
| TOTAL ALTERNATIVE COST | $6,049,000 |

Annual Costs*

| | |
|---|---|
| Power | 19,000 |
| Personnel | 60,000 |
| Supplies, Equipment, etc. | 19,000 |
| TOTAL ANNUAL O&M COST | $ 98,000 |

*Averaged over 20 years, including 10 years on interim supplies and 10 years on Power Creek supply.

Alternative 3 - Eyak Lake

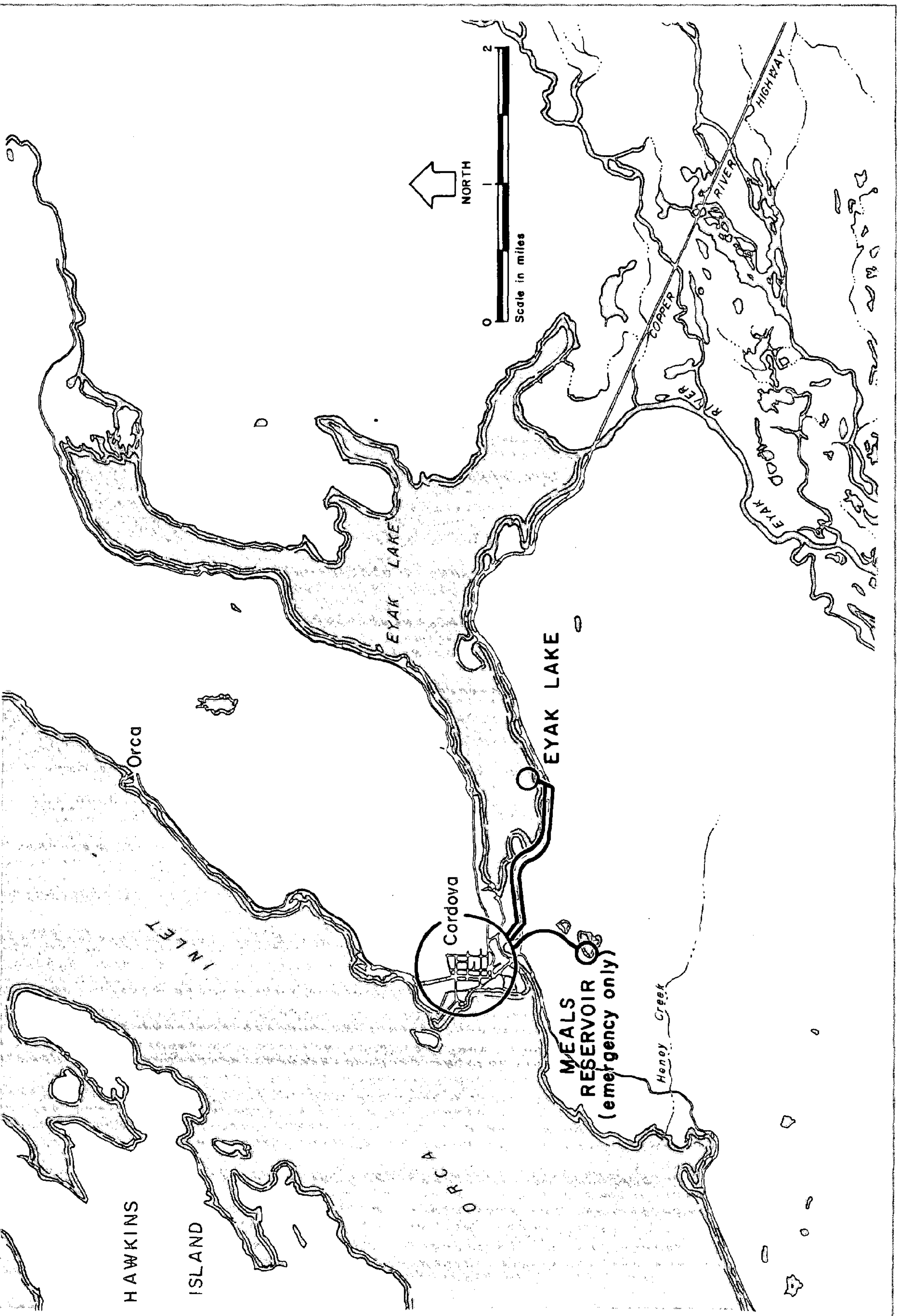
Alternative 3 utilizes Eyak Lake as the sole source of supply. This alternative utilizes the water treatment plant identified with the common supply facilities and would be used for the entire 12 months of each year. The water treatment plant would be located on the southern shore of Eyak Lake and would utilize the existing transmission line presently in service from Murcheson Falls Creek. Alternative 3 would require the construction of a 12-inch transmission line parallel to the existing 12-inch line along the Copper River Highway. Meals Reservoir would be improved and maintained as an emergency supply.

This alternative is presented graphically in Figure 5-4, with associated costs presented in Table 5-5.

Table 5-5. COST SUMMARY - ALTERNATIVE 3
EYAK LAKE

| | |
|---|---|
| Capital Costs | |
| Eyak Lake | |
| Treatment plant | $ 833,000 |
| Transmission line, 12-inch | 425,000 |
| Meals Emergency Supply | $ 220,000 |
| Total capital cost | 1,478,000 |
| 30% Contingency, Engineering, Legal, etc. | 443,000 |
| TOTAL ALTERNATIVE COST | $1,921,000 |
| Annual Costs | |
| Power | $ 185,000 |
| Personnel | 77,000 |
| Supplies, equipment, etc. | 28,000 |
| TOTAL ANNUAL O&M COST | $ 290,000 |

Figure 5-4 ALTERNATIVE 3— EYAK LAKE



Alternative 4 - Murcheson and Crater

Alternative 4 would utilize both Murcheson Falls Creek and Crater Lake as principal sources of supply. Rather than taking the water directly from Crater Lake, however, this alternative assumes a diversion facility on the downstream tributary from Crater Lake near Orca at elevation 195. The location of the diversion facility would permit the operation of the supply source without the use of automatic control valves. This would be similar to the operation of Murcheson Falls supply. It should be noted that this alternative is the only one which presents some potential for the development of power associated with the water supply project. The development of a joint water supply and power project was considered and is presented as Alternative 7.

Alternative 4, utilizing the diversion near Orca, would require approximately 13,000 feet of 18-inch transmission main from the diversion facility to the distribution system in town. A disinfection system for this supply would also be required.

Improvements at Murcheson Falls and Eyak Lake would be similar to those identified for Alternative 1. Once again, the Eyak Lake treatment plant would be utilized as a winter-only supply when adequate quantities are not available from the principal sources.

This alternative is presented graphically in Figure 5-5, with associated costs presented in Table 5-6.

Figure 5-5 ALTERNATIVE 4 AND 7 - MURCHESON FALLS - CRATER LAKE

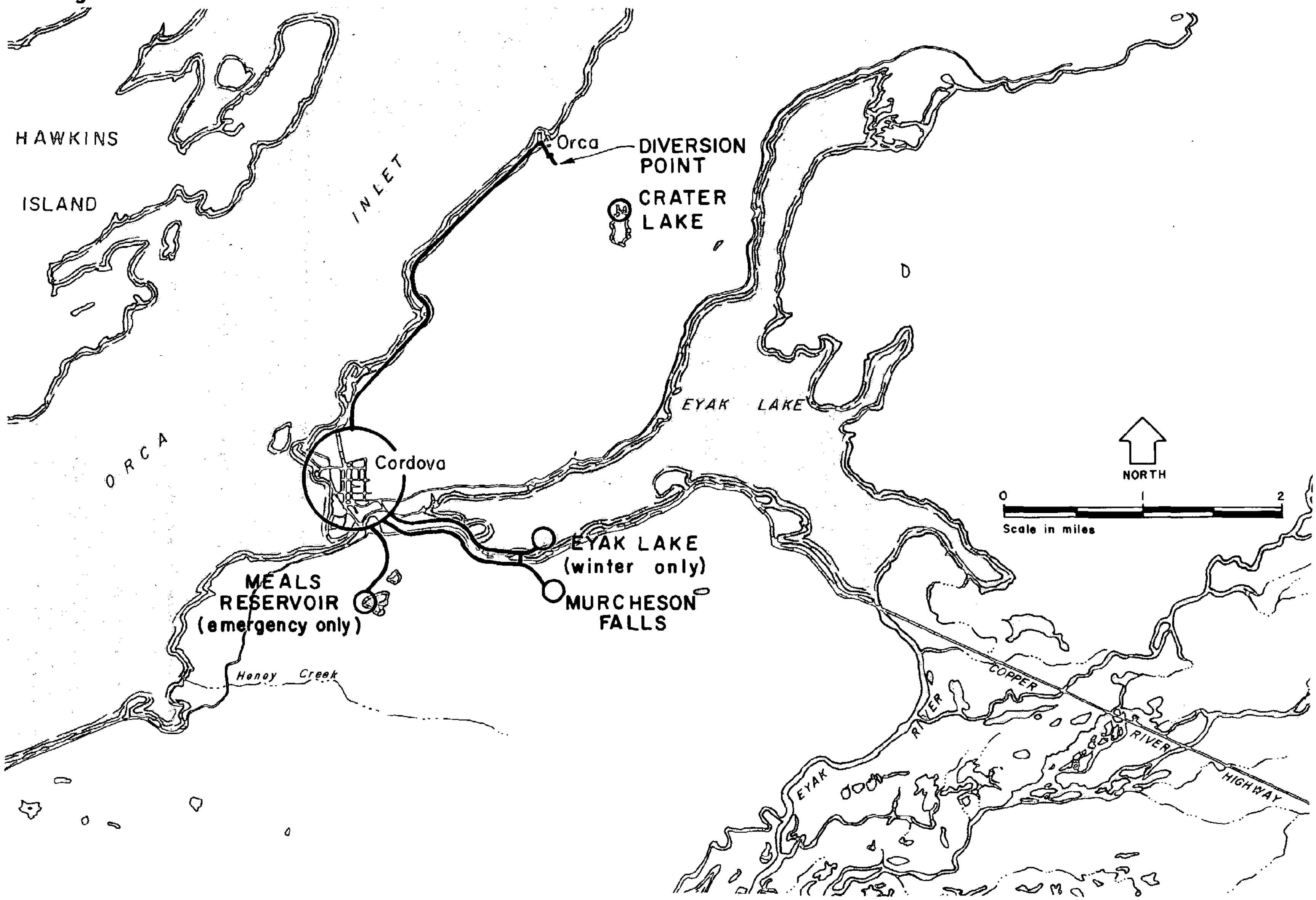


Table 5-6. COST SUMMARY - ALTERNATIVE 4
MURCHESON AND CRATER

| | |
|---|---|
| Capital Costs | |
| Murcheson Falls Creek | |
| Catchment improvements | $ 85,000 |
| Transmission line, 18-inch | 500,000 |
| Crater Lake | |
| Catchment and intake facilities | 182,000 |
| Transmission line, 18-inch | 1,340,000 |
| Chlorination and metering | 66,000 |
| Eyak Lake Treatment Plant | 833,000 |
| Meals Emergency Supply | 220,000 |
| Total capital cost | $3,226,000 |
| 30% Contingency, Engineering, Legal, etc. | 968,000 |
| TOTAL ALTERNATIVE COST | $4,194,000 |
| Annual Costs | |
| Power | $ 34,000 |
| Personnel | 30,000 |
| Supplies, equipment, etc. | 22,000 |
| TOTAL ANNUAL O&M COST | $ 86,000 |

Alternative 5 - Murcheson Reinforced

Alternative 5 would utilize Murcheson Falls Creek as the primary source of supply, with reinforcement from the watershed immediately to the west. Meals Lake will function as an emergency and a secondary supply source. The Heney Creek tributary will continue to be maintained with minimal capital improvements to the catchment facility and the transmission line. Specifically, these improvements will include replacement of approximately 200 feet of transmission line on the side of the canyon wall in Heney Creek Canyon and the modification of the catchment to allow easier maintenance. These improvements will, hopefully, be sufficient to keep the system operating as a secondary source to Murcheson Falls for a ten-year period. During the winter months, or during prolonged periods of dry weather, Meals Lake will be drained to its practical limit. When both Murcheson Falls and Meals Lake are depleted, Eyak Lake will serve as the emergency source. Beyond ten years, it is expected that hydroelectric power will be developed which will cause the pumping and treating of water from Eyak Lake to be more economical, thus removing the need to maintain the Heney Creek supply in case of a major failure.

The improvements necessary at Murcheson Falls would include the same improvements required for Alternative 1. Reinforcement of Murcheson Falls Creek would involve the construction of a diversion facility on the main tributary creek in the adjacent watershed and a transmission line from the new diversion facility to the Murcheson Falls Creek watershed. This additional supply into the Murcheson Falls drainage would not make the supply dependable year-round, but would minimize the length of time that treated water from Eyak Lake would be required. The water treatment plant for Eyak Lake would be similar to that described in Alternative 1, including the joint utilization of a disinfection system for both the Eyak Lake and Murcheson Falls Creek supplies.

This alternative is presented graphically in Figure 5-6, with associated costs presented in Table 5-7.

Figure 5-6 ALTERNATIVE 5- MURCHESON FALLS REINFORCED

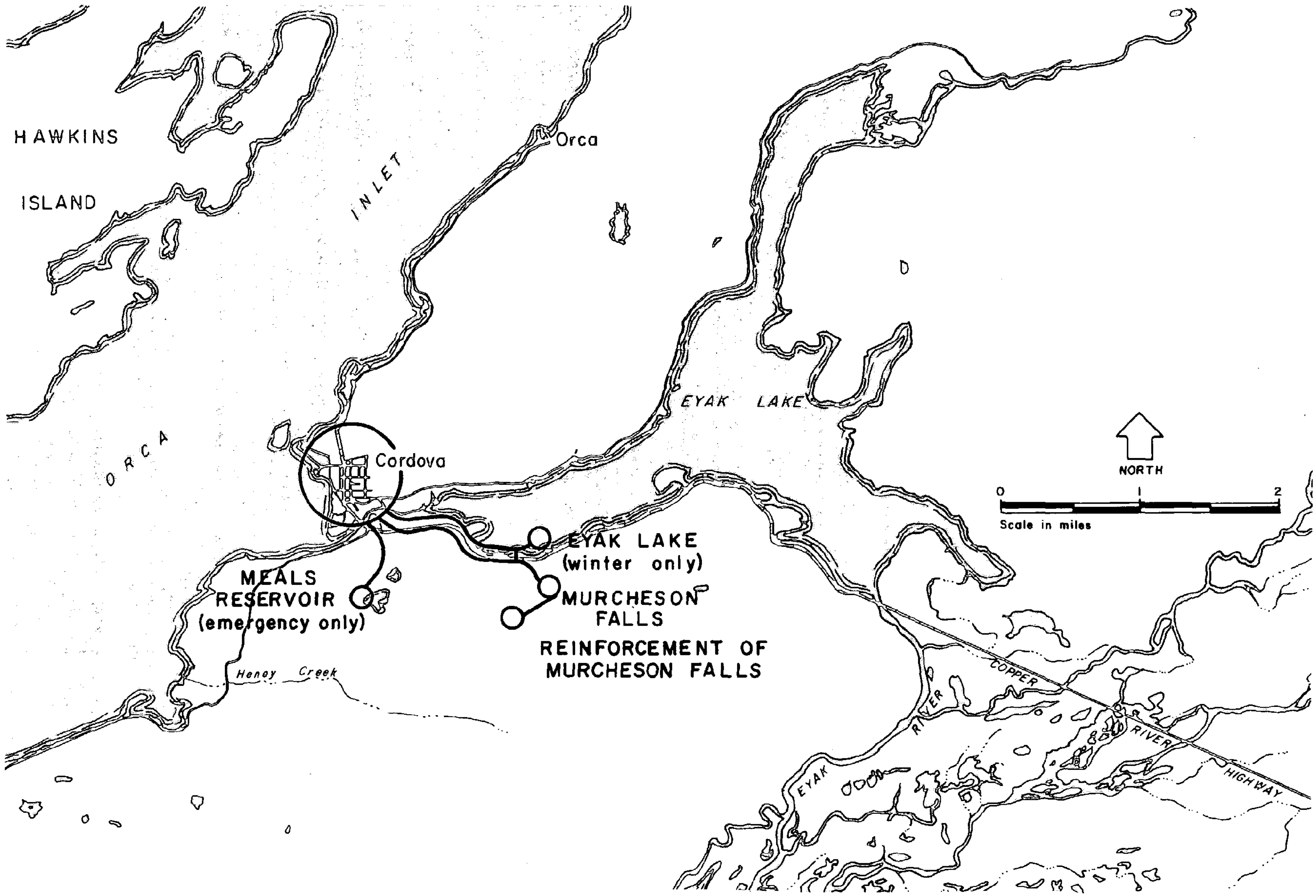


Table 5-7. COST SUMMARY - ALTERNATIVE 5
MURCHESON REINFORCED

| | |
|---|---|
| **Capital Costs** | |
| Murcheson Falls Creek | |
| Catchment improvements | $ 85,000 |
| Transmission line, 18-inch | 500,000 |
| Reinforcement diversion and transmission | 474,000 |
| Eyak Lake Treatment Plant | 833,000 |
| Meal Emergency Supply | 220,000 |
| Total capital cost | 2,112,000 |
| 30% Contingency, Engineering, Legal, etc. | 634,000 |
| TOTAL ALTERNATIVE COST | $2,746,000 |
| **Annual Costs** | |
| Power | $ 34,000 |
| Personnel | 28,000 |
| Supplies, equipment, etc. | 21,000 |
| TOTAL ANNUAL O&M COSTS | $ 83,000 |

Alternative 6 - Murcheson and Eyak

Alternative 6 would utilize Murcheson Falls Creek as the primary source of supply, with Eyak Lake serving all supplemental demands. This would include the low flows during the winter as well as supplemental flows during the remainder of the year. This alternative is identical to Alternative 5, with the exception that it does not include any reinforcement from the adjacent watershed. The reduced capital cost of not installing a diversion facility and transmission line from the adjacent watershed would necessitate increased power costs due to the more frequent use of the Eyak Lake treatment plant. It has been assumed that four months of operation would be required instead of two months for the "winter-only" alternatives.

This alternative is shown graphically in Figure 5-7, with associated costs presented in Table 5-8.

Alternative 7 - Murcheson and Crater with Power

Alternative 7 is similar to Alternative 4, except that the Crater Lake supply diversion facilities are modified to incorporate a hydroelectric generation facility.

The relatively small dependable quantity of water available from the Crater Lake tributary requires that the water be used twice, first for power generation and then for water supply. In order to accomplish both purposes, a diversion facility must be constructed at an elevation approximately 450 to 500 feet above sea level. A transmission line, or penstock, would carry the water from the diversion dam to a turbine-driven generator. The turbine would be designed to use about 200 feet of head to produce approximately 75 kilowatts of power, leaving 200 feet of head to supply water to the community. Major components of the power-generation facility include the following:

Figure 5-7 ALTERNATIVE 6 - MURCHESON FALLS - EYAK LAKE

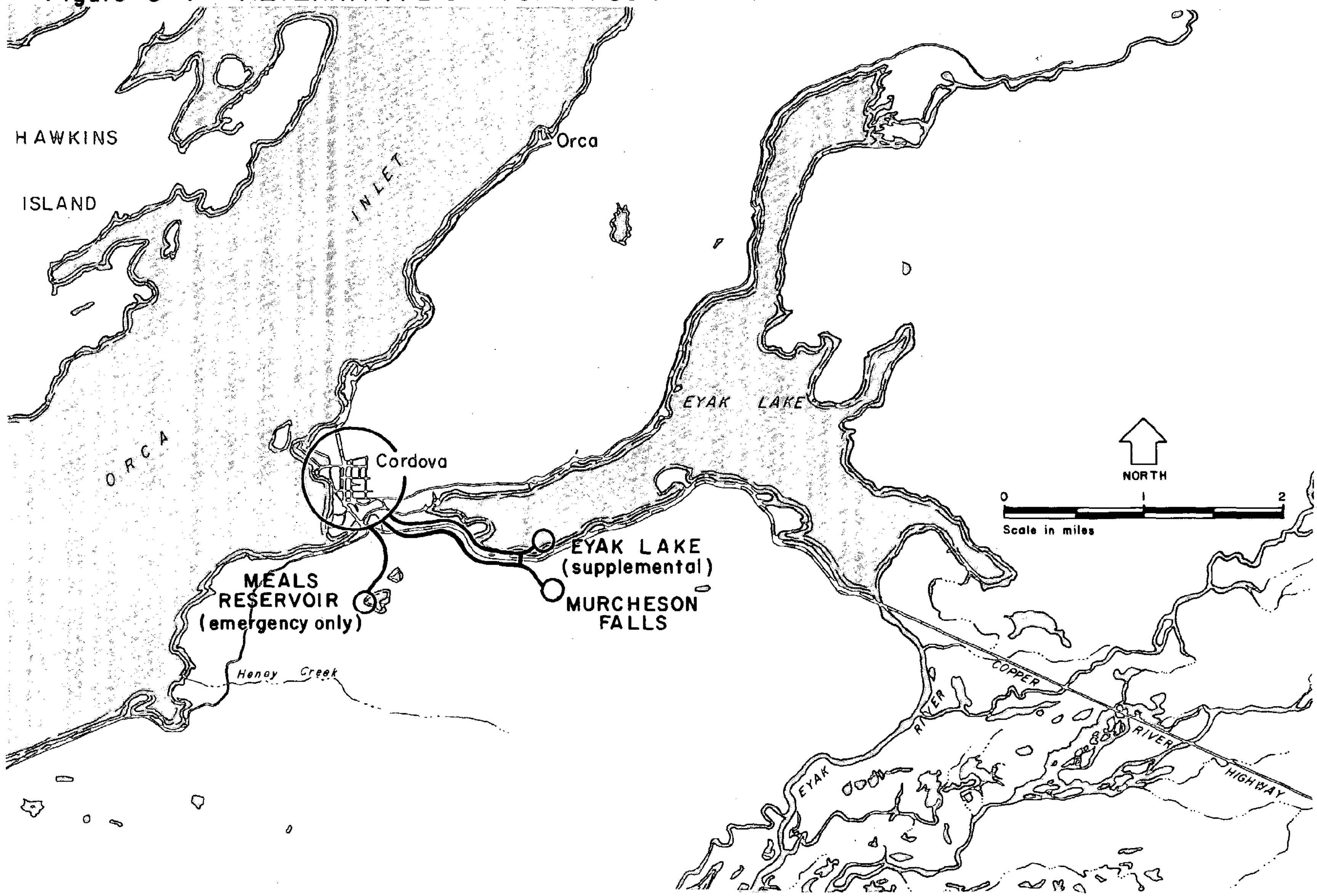


Table 5-8. COST SUMMARY - ALTERNATIVE 6
MURCHESON AND EYAK

| | |
|---|---|
| Capital Costs | |
| Murcheson Falls Creek | |
| Catchment improvements | $ 85,000 |
| Transmission line, 18-inch | 500,000 |
| Eyak Lake Treatment Plant | 833,000 |
| Meals Emergency Supply | 220,000 |
| Total capital costs | $1,638,000 |
| 30% Contingency, Engineering, Legal, etc. | 491,000 |
| TOTAL ALTERNATIVE COST | $2,129,000 |
| Annual Costs | |
| Power | $ 60,000 |
| Personnel | 53,000 |
| Supplies, equipment, etc. | 40,000 |
| TOTAL ANNUAL O&M COST | $ 153,000 |

Diversion Facilities

Penstock

Power Station, including

- Turbine
- Generator
- Control Valving
- Bypass Piping
- Appurtenances

The size of the potential power-generating facilities is quite small in relation to the total needs of the community, and would not impact the capital cost of the diesel generation equipment. It may not be appropriate, therefore, to make comparisons based on revenues from the sale of the power which reflects the total cost to a customer, i.e., $0.155 per kilowatt-hour. It may be more appropriate to compare the cost of fuel saved by the use of the alternate electrical power source.

Based on information provided by Mr. Douglas Bechtel, the current cost of fuel required to produce one kilowatt-hour of electricity is approximately $0.07. The production of 75 kilowatts of power for a continuous 10-month period would result in a savings in fuel costs of $38,000 annually.

Costs associated with the development of this joint power and water supply project are presented in Table 5-9.

Table 5-9. COST SUMMARY - ALTERNATIVE 7
MURCHESON AND CRATER WITH POWER

| | |
|---|---|
| <u>Capital Costs</u> | |
| <u>Murcheson Falls Creek</u> | |
| Catchment improvements | $ 85,000 |
| Transmission line, 18-inch | 500,000 |
| <u>Eyak Lake Treatment Plant</u> | 833,000 |
| <u>Meals Emergency Supply</u> | 220,000 |
| <u>Crater Lake</u> | |
| Transmission line, 18-inch | 1,200,000 |
| Chlorination and metering | 66,000 |
| Power project facilities | 1,140,000 |
| Total capital cost | $4,044,000 |
| 30% Contingency, Engineering, Legal, etc. | 1,213,000 |
| TOTAL ALTERNATIVE COST | $5,257,000 |
| <u>Annual Costs</u> | |
| Power | $ 36,000 |
| Personnel | 40,000 |
| Supplies, equipment, etc. | 24,000 |
| TOTAL ANNUAL O&M COST | $ 100,000 |
| Fuel Savings - Annual Credit (Based on $0.07 per KWH) | $ (38,000) |

## SUMMARY COMPARISON OF ALTERNATIVES

The following information is presented to allow a comparison of the alternative systems with respect to each other and with respect to the attainment of the project objectives. The alternatives will be discussed and pertinent study results will be summarized in the three specific areas of: (1) economic comparisons, (2) manpower and energy considerations, and (3) noneconomic considerations.

### Economic Comparisons

A summary of the capital and operation and maintenance (O&M) costs for each alternative is presented in Table 5-10. Also included are the estimated capital and O&M costs for the common distribution system improvements necessary for all alternatives.

Capital costs in Table 5-10 include the total capital cost for all stages of construction within the 20-year project life. The capital costs contain a 30 percent contingency factor, which includes a construction contingency and engineering administration and legal costs associated with the project.

The operations and maintenance costs in Table 5-10 represent the total cost on an annual basis of operating and maintaining all the project facilities. O&M costs include all manpower, energy, supplies, and equipment.

The total annual cost represents a summation of the annual O&M costs for the facilities and the annualized cost of the capital improvements over an assumed 20-year project life, with a 5 percent interest rate for bond financing. Even though many of the project facilities have a useful life in excess of 20 years, the foregoing assumption provides a convenient way of making rational comparisons of all alternatives.

Comparing the capital costs alone, Alternative 3, which uses Eyak Lake as the sole source of supply, is lowest, and Alternative 2, which uses Power Creek as the sole source of supply, is the highest.

Table 5-10. ECONOMIC COMPARISON OF ALTERNATIVES

| Alternative Water Supply System | Capital[a] Costs 1980, $ | Annual O&M Cost 1980, $ | Total Annual Cost[b] Without Grant | With 50% Grant | Ranking[c] |
|---|---|---|---|---|---|
| 1. Murcheson Falls Creek and Heney Creek | 3,886,000 | 114,000 | 426,000 | 270,000 | 4 |
| 2. Power Creek | 6,049,000 | 98,000 | 583,000 | 341,000 | 6 |
| 3. Eyak Lake | 1,921,000 | 290,000 | 444,000 | 367,000 | 5 |
| 4. Murcheson Falls Creek and Crater Lake | 4,194,000 | 86,000 | 423,000 | 254,000 | 3 |
| 5. Murcheson Falls Creek - Reinforced | 2,746,000 | 83,000 | 303,000 | 193,000 | 1 |
| 6. Murcheson Falls Creek and Eyak Lake | 2,129,000 | 153,000 | 324,000 | 238,000 | 2 |
| 7. Murcheson Falls Creek and Crater Lake with Power Project | 5,257,000 | 100,000 | 484,000[d] | 273,000[d] | |
| Common Distribution System Improvements | | | | | |
| Distribution Mains | 286,000 | 1,000 | 24,000 | 13,000 | |
| Storage Reservoirs | 1,529,000 | 19,000 | 141,000 | 80,000 | |
| Metering & Telemetry | 59,000 | 9,000 | 14,000 | 11,000 | |
| Total | 1,874,000 | 29,000 | 179,000 | 104,000 | |

[a] All project costs include 30% contingency factor for construction contingency; engineering, administrative, and legal costs.

[b] Based on an assumed 20-year project life and 5% interest on bond financing.

[c] Based upon total annual cost without consideration of grant funding.

[d] Includes a credit resulting from a savings in fuel costs of $0.07/KWH.

Comparing O&M costs for the various alternatives quickly shows that those alternatives which utilize the available head in the local watersheds have the lowest annual O&M costs, while those alternatives requiring the most pumping and treatment, Alternatives 3 and 6, have the greatest annual O&M costs.

Without the benefit of construction grant funds, Alternatives 5 and 6 are nearly equivalent in total annual cost, within 7 percent. The total annual costs of other alternatives are substantially more. Assuming a 50 percent grant on capital costs does not change the relative ranking of the more viable alternatives.

Alternative 7 contains costs and benefits arising from an integrated power-generation and water-supply project. Comparing this dual-purpose project to the most economical water supply project (Alternative 5) shows that, on a total annual cost basis, Alternative 7 is 60 percent and 41 percent more costly, depending on the assumption of no grant funds or 50 percent grant funds, respectively.

It should be noted that the alternative analyses in this report assume the cost of power to be $0.155 per kilowatt-hour (KWH) and the cost of diesel fuel to be $0.07 per KWH of electrical power produced, or approximately the present rates.

To demonstrate the effect of increased fuel and power costs, assume that over the life of the project, diesel fuel doubles to $0.14 per KWH of electrical power produced and the cost of electrical power increases to $0.25 per KWH. On a total annual cost basis, Alternative 7 would then be 44 percent and 20 percent more costly than Alternative 5, depending on the assumption of no grant funds or 50 percent grant funds, respectively. The likelihood of power costs reaching this level, or even higher, suggests that a joint water supply and power project on the Crater Lake supply may warrant further consideration.

### Manpower and Energy Considerations

The two most important components of O&M costs identified in Table 5-10 are the personnel and energy requirements of the alternatives. For a project, system, or facility to be functional and dependable in the Cordova area, it must use the minimum amount of energy, which is in short supply; it must require the minimum amount of manpower; and it must utilize personnel with skill levels that are normally available in the City's public works staff.

The development of all alternatives took into account the desirability of low O&M commitments. The alternatives do differ, however, in their projected manpower and energy needs, resulting from tradeoffs between capital costs and O&M costs. In order to give the reader a clear look at these two important components of the alternatives analysis, they have been summarized in Table 5-11.

Noneconomic Considerations

The inaccessibility and unstable conditions of Heney Creek Canyon will continue to create a high-risk situation with Alternative 1 (Murcheson and Heney). The long-term operation and maintenance problems associated with the diversion structure, intake facilities, and transmission line in Heney Creek Canyon will always exist. The tremendous power contained in the high runoff flows, as witnessed in the past, cannot be economically contained, even after improvements have been made. It is for this reason that Heney Creek is not suitable as a long-term supply, and is being considered only as a secondary supply for a ten-year period, or until the facilities require extensive capital improvements.

Alternative 2, Power Creek, not only has the highest cost, but is also contingent on the implementation of a large-scale hydroelectric project on the Power Creek watershed. The uncertainty of the timing of such a project makes this alternative unattractive at this time. At the time that a power project is developed, the economics of a water supply system incorporated into the power project should be evaluated.

Even though Eyak Lake represents the most dependable source of supply, the full-time use of this source, as outlined in Alternative 3, shows the impact of the high cost of power on the O&M costs. The uncertain nature of future power costs in Cordova lends even more doubt as to the economic viability of Alternative 3.

Table 5-11. MANPOWER AND ENERGY REQUIREMENTS

| Alternative | Manpower Requirements: Description | Man-Mo/Yr | Energy Requirements: Principal Use | KWH/Year |
|---|---|---|---|---|
| 1. Heney and Murcheson | Treatment plant operator full time for 2 mo/yr, 1/4 time for 3 mo/yr, plus 1.5 man-mo/yr general system maintenance. | 4.3 | 2 months winter treatment and pumping | 225,000 |
| 2. Power Creek | Same as Alt. 1 for first ten years. Treatment plant operator full time for 12 mo/yr, plus .15 man-mo/yr general system maint. for second ten years. | 4.3 first ten years. 13.5 second | 2 months winter treatment and pumping for ten years, then treatment only beyond. | 225,000 |
| 3. Eyak Lake | Treatment plant operator full time for 12 mo/yr, plus 1 man-mo/yr general system maintenance. | 13.0 | Year-round treatment and pumping. | 1,230,000 |
| 4. Murcheson and Crater | Treatment plant operator full time for 2 mo/yr, 1/4 time for 3 mo/yr, plus 1 man-mo/yr general system maintenance. | 3.8 | 2 months winter treatment and pumping | 225,000 |
| 5. Murcheson Reinforced | Treatment plant operator full time for 2 mo/yr, 1/4 time for 3 months, plus 1 man-mo/yr general system maintenance. | 3.8 | 2 months winter treatment and pumping. | 225,000 |
| 6. Murcheson and Eyak | Treatment plant operator full time for 4 mo/yr, 1/4 time for 3 mo/yr, plus 4 man-mo/yr general system maintenance. | 5.2 | 4 months total treatment and pumping. | 425,000 |
| 7. Murcheson and Crater with Power Project | Same as Alt. 4, plus 1.5 man-mo/yr for maint. of power-generating facilities. | 5.3 | 2 months winter treatment and pumping | 238,000<br>(540,000)* |

*Generated by power project during 10 months per year.

Abbreviations: man-mo/yr = man-months per year
mo/yr = months per year
KWH/Year = kilowatt-hours per year

Developing Murcheson Falls and Crater Lake as principal sources of supply on the opposite sides of town has distinct advantages related to the dependability and reliability of the overall water system. The excellent quality of the Crater Lake supply and the ability to divert the water near Orca makes Alternative 4 very attractive.

Alternatives 5 and 6 make maximum use of existing facilities which have good accessibility, i.e., Murcheson Falls catchment and transmission line. The selection of either alternative will keep future options for alternative supplies open, while developing the full potential of the Murcheson Falls supply. Development of the water treatment plant at the proposed location on Eyak Lake near the east end of the Murcheson Falls transmission line will allow joint use of several necessary facilities, e.g., disinfection, metering, and monitoring system.

All of the alternatives have an effect on the environment. The most significant impacts are associated with disruption during construction. Those alternatives that minimize major construction projects and that require construction within existing accessible areas, rather than remote sites, would have the least negative environmental impacts. Applying these criteria to the alternatives shows that the development of Heney Creek, Alternative 1, and Power Creek, Alternative 2, would have the worst negative environmental impacts, and Alternative 3, utilizing only Eyak Lake, would have the least.

Any major stream diversion within a waterhsed would have a negative impact on the environs in the lower reaches of the watershed. Alternative 3, which uses only Eyak Lake, will have the least impact. Alternatives 1, 4, 5, and 6, which could result in the major portion of a natural streamflow being diverted, would have a greater impact. The extent to which the downstream watershed is utilized will partially determine the magnitude of the resulting impact.

The consumption of a nonrenewable natural resource is a long-term negative impact. Alternative 3, treatment and pumping from Eyak Lake, uses the greatest amount of energy, which is developed through the consumption of petroleum products, and commands the lowest rating in this category. Alternatives 4, 5, and 7, which minimize pumping and make maximum use of the existing head available from the tributary watersheds, are rated highest

# Chapter 6

# RECOMMENDED WATER SYSTEM

Based on the results of the water source feasibility study discussed in previous chapters of this report, Alternative 5, utilizing Murcheson Falls Creek as the principal source of supply with secondary supply from Meals Lake and winter-time auxiliary supply from Eyak Lake, is the recommended water supply system. The water supply facilities should serve the needs of the community of Cordova, Alaska, dependably and reliably for 50 years or more. Near the end of the 20-year planning period used in this study, it would be advisable for the City to review their water supply facilities and to update this report.

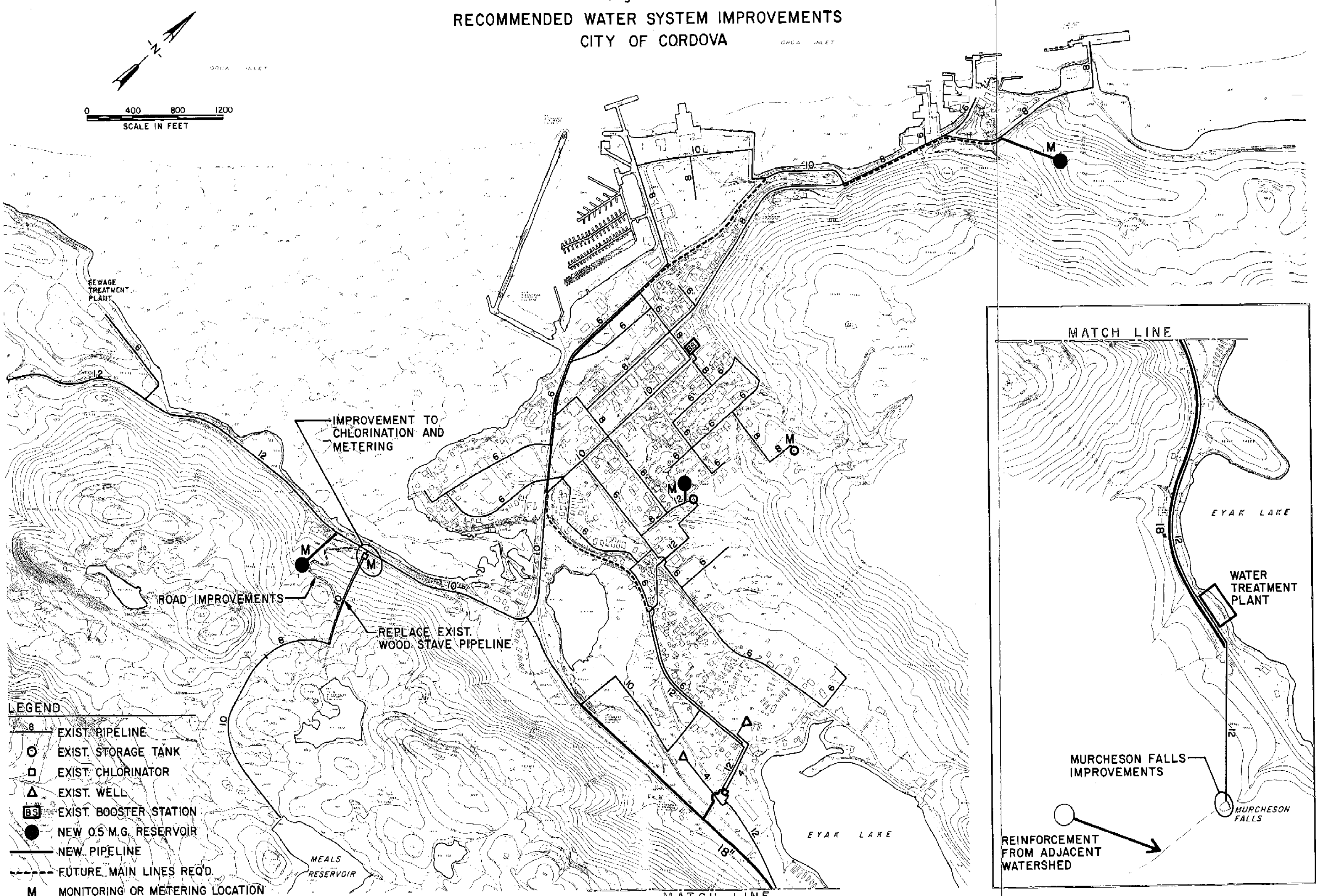
## PROJECT DESCRIPTION

Key elements of the recommended water supply system are shown in Figure 6-1 and described below. Recommended improvements include source facilities and distribution system improvements.

### Source Facilities

The major source facility to be constructed is a treatment plant on the south shore of Eyak Lake near the point of discharge of Murcheson Falls Creek. Improvements will be made to the Murcheson Falls diversion and intake facilities, and the existing Murcheson Falls transmission line will be improved by the installation of a pipeline parallel to the existing transmission main along the Copper River Highway.

Figure 6-1
RECOMMENDED WATER SYSTEM IMPROVEMENTS
CITY OF CORDOVA



The Murcheson Falls supply will be reinforced with the addition of a transmission line and catchment facility to make use of an adjacent watershed upstream of the facility.

The Heney Creek source will continue to be maintained for a period of approximately 10 years with minor improvements to the catchment basin and the transmission line.

Distribution System Improvements

Along with the improvements and additions to the source facilities, it will be necessary to make significant improvements to the distribution system, primarily in the areas of additional storage reservoirs and distribution mains. The project includes construction of 1.5 million gallons of ground-level storage. The storage would be divided into three separate reservoirs of 0.5 million gallons each. The location of these reservoirs, shown in Figure 6-1, is based on a very preliminary site investigation made during the course of this study. These sites will be investigated in detail during the preliminary design with consideration of planning, site availability, site and soil conditions.

In order to further provide for the proper operation of the complete supply system, it will be necessary to provide additional distribution system mains in the general areas shown in Figure 6-1. The most important area is along Railroad Avenue and Copper River Highway. The design of these distribution system improvements will utilize a computer network analysis technique to analyze the existing system, which will most efficiently locate problem areas and determine least-cost solutions.

To enhance the operation of the existing and proposed facilities, it is recommended that the City provide additional metering and monitoring facilities within the water supply system. By transmitting the monitored information to a common point for analysis and reporting, much of the existing manpower currently being used to accomplish the same task will be freed for other uses. Principal items to be included in the metering and monitoring would be continuous measurement of the flow from the major sources of supply, continuous monitoring of the water-surface level in each storage reservoir, and monitoring of the operation of the water treatment plant.

The metering and telemetry system will be developed with a flexibility to increase or to add to its monitoring capabilities to meet future requirements.

## PROJECT SCHEDULING

Project implementation will require that design and construction of the facilities be phased. The implementation schedule, presented as Figure 6-2, sets forth a realistic time period in which all the facilities may be designed, constructed, and put into service, providing immediate solutions to several major existing problems. As implementation begins on the first phase, additional engineering studies should begin on detailed site investigations and preliminary design of the reinforcement of Murcheson Falls Creek and should continue on the winter water-quality-monitoring program for Eyak Lake. Results of these studies are essential to the design and implementation of the most cost-effective second phase water supply project facilities.

## FINANCIAL CONSIDERATIONS

There are several components of the total project costs which can impact the water consumer in different ways. They include the capital cost of facilities, the method of financing, and operation and maintenance costs. Capital improvement costs are listed in Table 6-1. They are separated into 1980 first-phase facilities and 1981 second-phase facilities. No attempt has been made to separate the engineering design costs from the overall 30 percent contingency and engineering factor.

It has been assumed that a grant would be available to finance 50 percent of the capital improvement costs and the remaining costs would be financed through a 40-year loan at 5%-interest rate.

Based on the above assumptions, the annualized cost of the capital improvements for the recommended alternative would be $135,000. Adding the estimated 1980

Figure 6-2. IMPLEMENTATION SCHEDULE

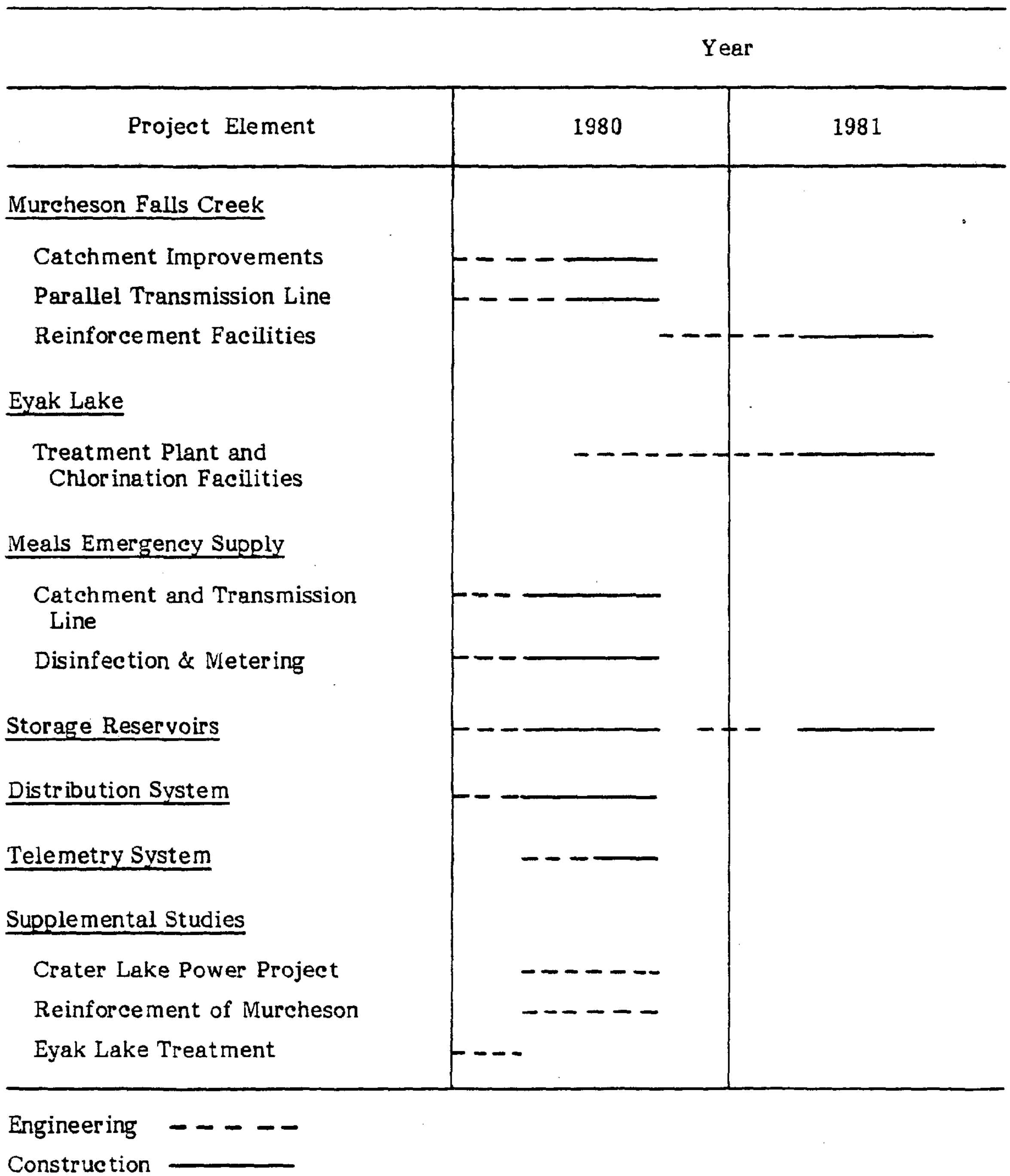


Table 6-1. CAPITAL COST SUMMARY - RECOMMENDED SYSTEM IMPROVEMENTS

| Project Element | 1980 | 1981 |
| --- | --- | --- |
| Murcheson Falls Improvements | $ 111,000 | |
| Transmission Line | 650,000 | |
| Murcheson Reinforcement | | $ 616,000 |
| Water Treatment Plant | | 1,083,000 |
| Distribution Main | 286,000 | |
| Storage Reservoirs | 1,019,000 | 510,000 |
| Meals Emergency Supply Improvements | 286,000 | |
| Telemetry | 59,000 | |
| Totals | $2,411,000 | $2,209,000 |
| TOTAL PROJECT COSTS | $ 4,260,000 | |

O&M cost of $112,000 to the annualized capital cost gives a total first year annual cost of $247,000. Adding this cost to the City's 1979/80 budget for "Water Operation and Maintenance" of about $230,000 would cause the costs for total water service to approximately double. If the existing water rate structure did not change but was updated to take into effect the increased costs, the monthly cost to a residence would be approximately $25.00, and the metered production cost would be about $0.73 per 1000 gallons.

There are several things which will have an impact on the ultimate charge to the customer that cannot be accurately estimated at this time. They include savings in annual cost now required to operate and maintain the existing system, actual construction cost of improvements, amount of grant funds made available from other sources for construction, changes in the rate structure, and changes in water usage. Without a rate analysis, it is not possible to accurately reflect the increased costs back to a flat-rate charge or a metered water rate. It is recommended that such a rate analysis be performed.

For discussion purposes, based upon a 50 percent grant, there are three cost elements:

1. Annualized capital cost, including principal and interest,

2. Project operation and maintenance cost for the capital improvements, and

3. Existing operation and maintenance budget.

Based upon these elements, the monthly service charge for residential users would be between $18 and $25 per month.

An important factor in the net cost of water system improvements which should be considered is the effect on fire insurance rates. The proposed system improvements would easily permit the water system to qualify for the next higher rating. If the next higher rating were obtained following the implementation of the proposed project, it would result in an approximate ten percent (10%) reduction in fire insurance costs to both the industries and commercial establishments in Cordova.

# APPENDIX

## REFERENCES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BLACK & VEATCH
CONSULTING ENGINEERS

TEL. (916) 635 5780

2640 CORDOVA LANE, SUITE 103
RANCHO CORDOVA, CALIFORNIA 95670

April 11, 1980
File No. 0003.421

Mr. Perry D. Lovett
City Manager
City of Cordova
Post Office Box 1210
Cordova, Alaska 99574

Re: Cordova Water Supply Feasibility Study

Dear Mr. Lovett:

According to your request, based on Mr. Keith Kelton's letter dated March 12, 1980, we are submitting to you supplemental information regarding a potential project to develop Crater Lake as a year-round supply. We have no specific recommendation to make regarding the ultimate action to be taken concerning this alternative.

If the City does decide to pursue this alternative, we should reevaluate the implemantation schedule involving the second phase of the water supply improvements. The time that would be required to make the supplemental investigation and studies necessary prior to implementation of a Crater Lake Project will necessitate additional interim measures to satisfy the winter low-flow problems which are not alleviated by the first-phase facilities.

The attached information is a summary of a supplemental evaluation of the use of Crater Lake as a year-round supply by drawing directly out of the Lake and transporting by closed conduit to the distribution system.

We are confident that the enclosed information presents an accurate comparison of the Crater Lake alternative, giving advantages and disadvantages as we know them. The "Supplemental Evaluation" is provided as an attachment to this letter so that it may be used separately for review by Council Members or other interested parties, as you see fit.

I have taken the liberty of providing a copy of this letter and the attachment directly to Mr. Keith Kelton of the Department of Environmental Conservation.

If we can be of further service, please feel free to call.

Very truly yours,

BLACK & VEATCH

Harold L. Welborn

Harold L. Welborn

Attachment

cc: Mr. Keith Kelton
Mr. David Merrell

CORDOVA WATER SUPPLY FEASIBILITY STUDY

SUPPLEMENTAL EVALUATION

CRATER LAKE AS A YEAR-ROUND SUPPLY

## WATER QUALITY

The quality of water in Crater Lake was assumed to be as good or better than the quality determined from tests at Orca and reported in Table 4-1, Page 4-4, of the Report. Crater Lake is definitely the best potential source when one considers water quality and remoteness of source.

## WATER QUANTITY

The quantity of water available from Crater Lake is limited by the size of the watershed. During the conduct of the study, hydrological data was available, identifying the relatively small dependable supply that could be obtained from Crater Lake. The data indicated that the maximum total runoff into Crater Lake averaged only 2.1 mgd. (A recent Corps of Engineers study updated this figure downward to 1.6 mgd.) Storage required in Crater Lake to make use of 2 mgd, on a year-round basis, was 250 million gallons. To provide this year-round supply would require a controlled 30-foot fluctuation in the water surface, further requiring dams and a deep intake structure (or Lake tap).

The Chugach Alaskan Cannery at Orca presently derives its water supply from Crater Lake. Their water needs would have to be met from the available supply. Their present daily demand is estimated to be 0.6 mgd, similar to the St. Elias Cannery in Cordova. Assuming an increase in productivity similar to the increase forecast for the canneries in Cordova, the projected demand by 2020 would be 0.9 mgd. The dependable year-round supply from Crater Lake available to Cordova would be reduced, therefore, to 0.7 mgd. This small amount of available supply eliminates Crater Lake as a sole source of supply, regardless of economics.

If Crater Lake were used to supply the winter demand while other supplies were unavailable (e.g. during winter freezing), the facilities required would be the same as if it were a full-time supply. The taking of large amounts of water during the coldest winter months would have a similar effect on the Lake as would the continuous withdrawal, i.e. a large drawdown requiring fairly sophisticated facilities to maintain careful control. During the remainder of the year, the intake and transmission facilities would still be required to supply water to the Chugach Alaskan Cannery. During this same period of time, the City could not obtain water because of the need to refill the Lake.

## COST ANALYSIS

The development of a direct intake from Crater Lake, to make use of the available water for a year-round supply, or emergency-only supply, would include:

| | | |
|---|---|---|
| a. | Temporary diversion facility to maintain service to Orca Cannery while construction of the dam and intake structure. | $ 175,000 |
| b. | Dams required on the north and south ends of the Lake to raise the water level a minimum of ten feet to optimize drawdown versus capacity requirements. | 825,000 |
| c. | Intake structure on north end of the Lake at 30-foot depth, with necessary controls | 300,000* |
| d. | Approximately 6000 feet of high-strength steel pipeline, capable of handling up to 600 psi pressure, plus water hammer and surge, installed in practically inaccessible terrain. | 1,800,000* |
| e. | Remote monitoring of control facilities required at Crater Lake. | 80,000 |
| f. | Chlorination, Metering, Valving, and Pressure-Reducing Facilities near Orca. | 75,000 |
| | Total Estimated Construction Cost | $ 3,255,000 |

*It should be noted that preliminary Cost Estimates, made by the Corps of Engineers in Anchorage, estimate the cost of constructing a "Lake Tap" on Crater Lake at between $2 and $5 million.

Because Crater Lake does not represent a large part of the total supply needs, additional sources are required to produce a total water supply project; for example, Murcheson improvements, including parallel transmission line and reinforcement facilities. Without a very detailed hydrologic, hydraulic, environmental, and water rights investigation, it would not be possible to determine if a facility taking water directly out of Crater Lake could completely satisfy the needs being filled by the proposed treatment plant on Eyak Lake adjacent to the Copper River Highway.

_If_ it did prove feasible to eliminate the use of Eyak Lake water, the total estimated cost of the alternative would be:

| | |
|---|---|
| Crater Improvements | $ 3,255,000 |
| Transmission Main, Orca to Cordova | 1,340,000 |
| Murcheson Catchment Improvements | 85,000 |
| Murcheson Reinforcement Facilities | 474,000 |
| Meals Emergency and Secondary Supply (Perhaps not needed) | ~~220,000~~ |
| Chlorination Metering and Valving at Murcheson Falls | 65,000 |
| Total Construction Cost | $ 5,219,000 |
| + 30% Construction Contingency, Legal, Administration, Etc. | 1,566,000 |
| TOTAL ESTIMATED PROJECT COST | $ 6,785,000 |
| Annualized Capital Cost, 20 Years @ 5% | $ 544,000 |
| Annualized Capital Cost, 50% Grant, 20 Years @ 5% | $ 272,000 |

The above estimate does not include the common distribution system improvements. The above annualized costs, with and without assumed 50% Construction Grant Funds, can be compared directly with the Alternatives in Table 5-10, Page 5-30, of the Cordova Water Supply Feasibility Study. A copy of Table 5-10 is attached for the convenience of the reader.

It is estimated that the annual savings in O&M, if the treatment plant were not required, would be $60,000. It is estimated that the annual O&M associated with the Crater Lake facilities would average at least $25,000. The net decrease of $35,000 would result in a total annual O&M cost of $48,000 for this alternative.

The total annual cost for comparison with other alternatives in Table 5-10 of the Report is $592,000 and $320,000 annually, depending on the assumption of No Grant or 50% Grant, respectively. With the 50% Grant, this alternative would cost approximately 66% more annually than the least-costly alternative.

## NON-ECONOMIC FACTORS

In addition to the economic factors just mentioned, there are several uncertainties regarding the use of Crater Lake, which include: (1) water rights; (2) environmental effect of fill-and-draw cycle; (3) right-of-way acquisitions; (4) severe inaccessibility, especially during the winter; and (5) the very tenuous nature of construction cost estimates due to the inaccessibility of the site.

The potential for producing power from a joint water and hydropower facility does exist. The Corps of Engineers is presently performing preliminary studies to better define this possibility. If joint facilities could be implemented, the alternative of taking water directly from Crater Lake may become more advantageous.

MERRELL & ASSOCIATES/BLACK & VEATCH
Harold L. Welborn
April 11, 1980